ONTARIO POWER AUTHORITY

1

Supply Mix Advice Report

Volume 1 – December 2005

Ontario Power Authority

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December 9, 2005

The Honourable Donna Cansfield
Minister of Energy
900 Bay Street, 4th Floor
Toronto, ON M7A 2E1

Dear Minister:

I am pleased to provide the enclosed *Supply Mix Advice Report*, which presents the Ontario Power Authority's recommendations on options for the future development of Ontario's electricity system. The report is in response to a request on May 2, 2005 (letter attached) from your predecessor, the Honourable Dwight Duncan.

In preparing the report, the OPA sought the advice of a range of experts, as well as input from industry and non industry stakeholders. I would like to acknowledge the valuable time, insights and information contributed by these organizations and individuals – more than 200 participants – in helping the OPA to develop its recommendations.

Yours truly,

Jan Carr
Chief Executive Officer

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MAY - 2 2005

Mr. Jan Carr
Chief Executive Officer
Members of the Board
Ontario Power Authority
608-175 Bloor Street East
North Tower
Toronto, Ontario
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Dear Mr. Carr and Members of the Board:

Re: Commencement of long-term planning exercise and request for recommendation on supply mix

It is my pleasure to request that the Ontario Power Authority (the OPA) begin the process of developing a proposed Integrated Power System Plan.

It has been many years since a comprehensive, long-term plan for electricity has been prepared for the Province of Ontario, as has been widely noted. The task you will be embarking on will be of historic importance, and will provide a crucial foundation for a clean, reliable, diverse and sustainable electricity supply for the province.

In order to ensure that the Integrated Power Supply Plan conforms closely to the values and wishes of the people of Ontario, section 25.30 (2) of the *Electricity Act, 1998,* allows the Minister, on behalf of the government and the people of the province, to issue directives relating to overall goals for the plan. These goals include:

a) the production of electricity from particular combinations of energy sources and generation technologies;
b) increases in generation capacity from alternative energy sources, renewable energy sources or other energy sources;
c) the phasing-out of coal-fired generation facilities; and
d) the development and implementation of conservation measures, programs and targets on a system-wide basis or in particular service areas.

.../cont'd

In order to provide assistance to the government in its deliberations prior to issuing such directives, I am requesting a report addressing these matters to be delivered to the government by December 1, 2005, based on the OPA's internal resources, the government's plan to replace coal-fired generation in Ontario, expert advice solicited from Ontario and abroad, and stakeholder input in a manner developed at the discretion of the OPA. The report should include:

- recommendations with respect to conservation targets for Ontario for 2015, 2020 and 2025, taking into account the target already set by the Government of Ontario for 2007;
- recommendations with respect to additions of new renewable energy capacity by 2015, 2020 and 2025, taking into account the targets already set by the Government of Ontario for 2007 and 2010; and
- recommendations with respect to the appropriate mix of electricity supply sources to satisfy the remaining expected demand in Ontario, after conservation and renewable sources have been taken into account, and with particular attention to baseload, intermediate and peak availability of energy.

Sincerely,

Dwight Duncan
Minister

Supply Mix Advice Report

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Supply Mix Advice Report

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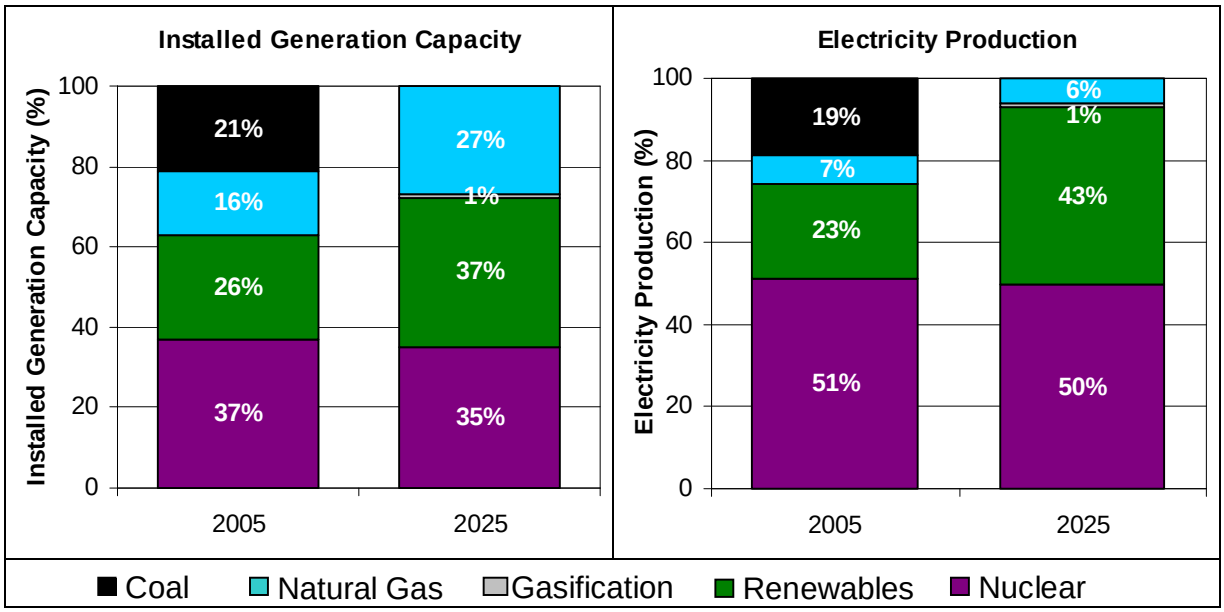
1.1 Supply Mix Summary

This report presents recommendations of the Ontario Power Authority (OPA) to the Minister of Energy on options for the future development of Ontario's electricity system. It responds to a request from the Minister on May 2, 2005 for advice on the appropriate mix of electricity supply sources to satisfy the expected demand in Ontario, taking into account conservation targets and new sources of renewable energy out to 2025.

Figure 1.1.1 shows the mix of installed generation capacity and the contribution of each source to meeting electricity production requirements at present and by 2025, based on the recommendations of this report. (Definitions of capacity and other technical terms appear in the glossary in Part 1.6.)

Figure 1.1.1: Direction for Ontario's Electricity System Development



Source: OPA; Note: Figures shown take into account the reduction in demand due to conservation activities

The recommendations would increase the share of renewable sources in Ontario's supply mix, maintain the share of nuclear generation, and replace coal by increasing the share of gas-fired generation and renewable resources.

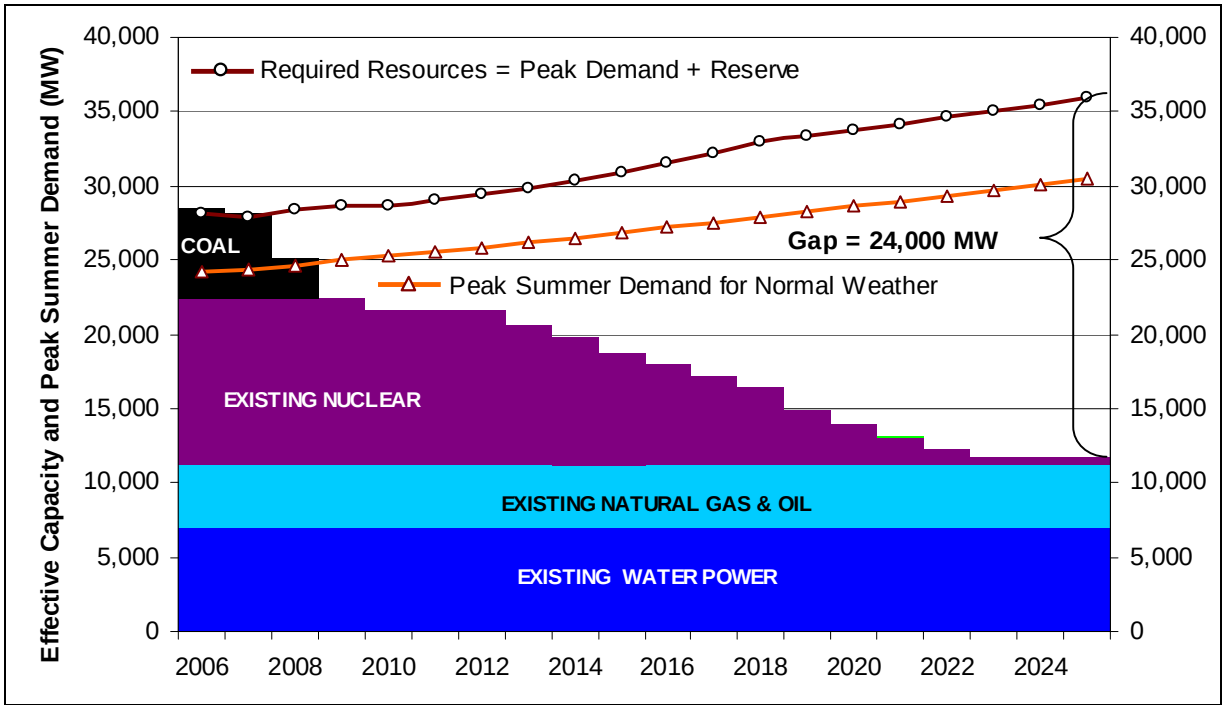
Ontario's electricity sector is at one of the most challenging points in its history. The system has less capacity today than it did 12 years ago, while demand has increased because of population

and economic growth. This is particularly true in downtown Toronto and the Greater Toronto Area, where facilities were shut down and load has grown faster than the provincial average.

As Figure 1.1.2 shows, a projected province-wide shortfall in supply capacity emerges later in this decade and grows rapidly over time. The shortfall stems primarily from Ontario's shrinking supply, with growth in demand as an important secondary factor.

The nature of the problem is clear: a lack of investment to expand electricity capacity in Ontario in the past decade. With supply already tight as a result of this under-investment, the sector faces the loss of a major part of its current supply mix as most units of its nuclear fleet reach the end of their design life over the next several years. The loss of nuclear generation would come immediately on the heels of replacement of coal-fired stations, scheduled for completion by 2009. Together, the combination of demand growth and generation retirements would create a gap of roughly 24,000 megawatts (MW) by 2025, equivalent to about 80% of Ontario's current capacity.

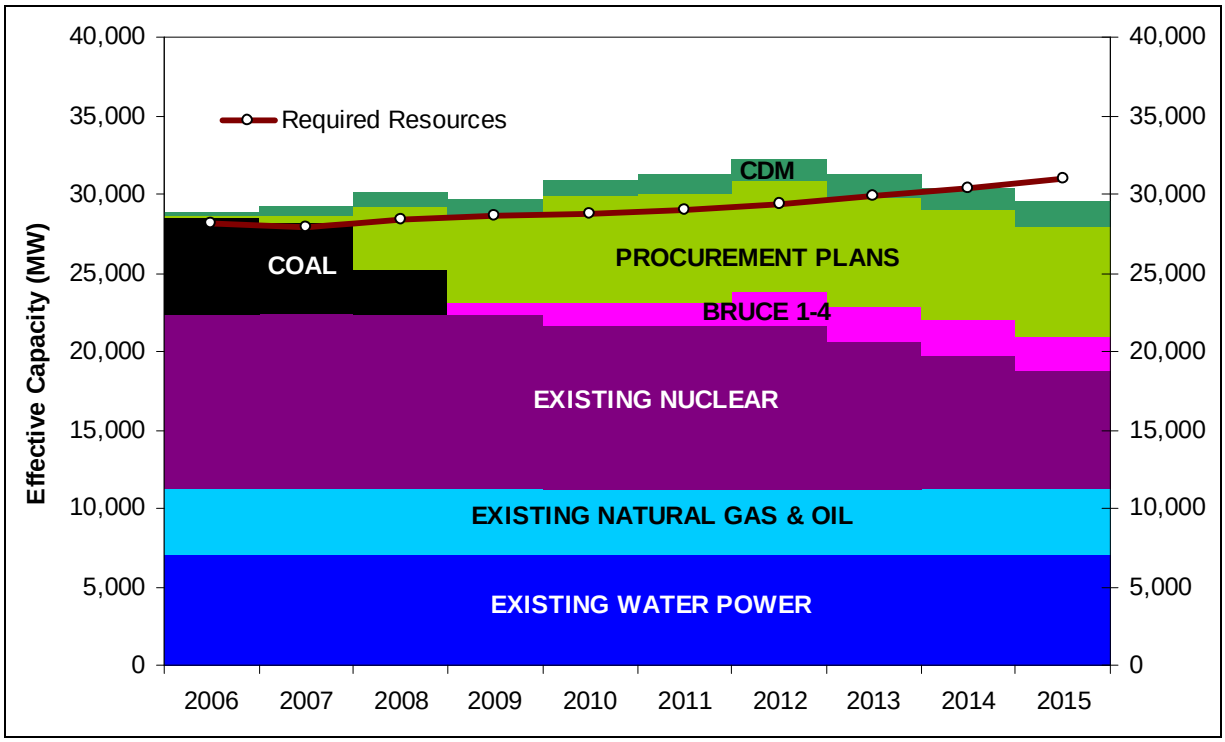
Figure 1.1.2: Demand Growth and Generation Retirements Define Challenge



Source: OPA

Procurements and other initiatives, as shown in Figure 1.1.3, are under way to balance supply and demand in the mid term. By roughly 2013, however, increasing demand and loss of nuclear capacity will once again overwhelm the ability of the system to meet needs.

Figure 1.1.3: Current Procurement Initiatives and CDM Cover Needs to 2014



Source: OPA

The focus of this advice, then, is on the best way to meet needs over the long term, specifically by 2015, 2020 and 2025. Analysis has shown that, because the most attractive options needed in the longer term involve long lead times, decisions are needed soon to ensure that electricity consumers in Ontario benefit from a reliable and affordable mix of supply sources.

Planning supply mix would be simple if a single resource were superior to others in all areas – environmental impact, reliability and costs – and could meet equally well the needs of base, intermediate and peak load. The reality is that no such single resource exists – a combination of resources and technologies is needed, and tradeoffs and synergies among them must be considered.

The Starting Point

In approaching the task of advising on how to meet this challenge, we recognized three Ontario Government policies already established as priorities:

- Creation of a conservation culture
- Preference for renewable sources of energy, and

- Replacement of coal-fired generation for environmental and health reasons

These policies are consistent with evidence that responsible stewardship of the environment requires more intelligent use of carbon-based energy sources. The Government has stated that its first concern is reliability of supply and that its policy objectives are subject to maintaining reliable supply.

With this public policy framework as a starting point, a number of principles further guided the development of this advice.

- *Listening*: Any plan for Ontario's energy future must reflect the values and concerns of its citizens.

- *Sustainability*: Choices and directions need to be put on a path to sustainability – for Ontario's environment, economy and people – over the long term.

- *Flexibility*: Advice must consider the need to adapt to changing circumstances.

- *Embracing the Future*: Advice and plans must be forward-looking, open to new possibilities and technologies, and willing to tackle difficult choices.

- *Managing Risks:* The economic, environmental and reliability risks of potential supply sources must be explicitly recognized, and options combined in ways to mitigate or avoid these risks.

- *Prudence:* Finding the right balance among choices without unnecessarily exposing consumers to unacceptable risks represents the prudent course that people in Ontario expect.

Consultations with stakeholders and members of the public provided insight into specific concerns, as well as broader values. There was wide consensus that reliability of supply was the single most important concern, and that stable rates and environmental considerations also ranked as high importance.

Elements of a Solution

Taking into account the nature of the problem and given the framework for analyzing choices, certain broadly defined elements of a solution became evident:

1. Conservation and other forms of demand management must be a major part of any plan:

- We explored a range of gains from 1,800 to 4,300 MW that might be achieved through greater energy efficiency, demand reduction and demand response measures, in addition to the expected impact of current initiatives and assumptions, and in addition to 1,000 MW of natural gas-fired cogeneration.
- For the purposes of long-term planning, the 1,800 MW estimate (5% of requirements) was considered a reasonable and prudent assumption at this stage, because of the high level of certainty that it will be achieved. This is not the target of the OPA's Chief Energy Conservation Officer.
- We believe it is possible that Ontario can achieve a greater gain. As confidence about achievable conservation grows, the plan can adapt to the changes.
- OPA's Conservation Bureau has an objective of achieving the greatest possible amount of conservation, and there is flexibility in the plan to incorporate increases in conservation estimates.

2. Renewables offer considerable potential, especially in the longer term:

- Renewables, including wind, small hydro (waterpower) projects and hydro purchased from other provinces (referred to as "hydro imports" in the balance of this report), can provide a significant share of capacity and energy.
- It is clear, however, that putting in place the infrastructure needed to harvest the most promising sources, hydro imports and large-scale wind generation, will take considerable time and money.
- There are additional policy and regulatory constraints on some of these opportunities – a review to explore the potential and alternatives for facilitating development is advisable.

Together, conservation and new renewable sources would more than meet all of Ontario's growth in demand for electricity by 2025. This would not, however, replace the loss of capacity from the retirement of other supply sources. Ensuring enough supply means turning next to an analysis of conventional sources. The conclusions are:

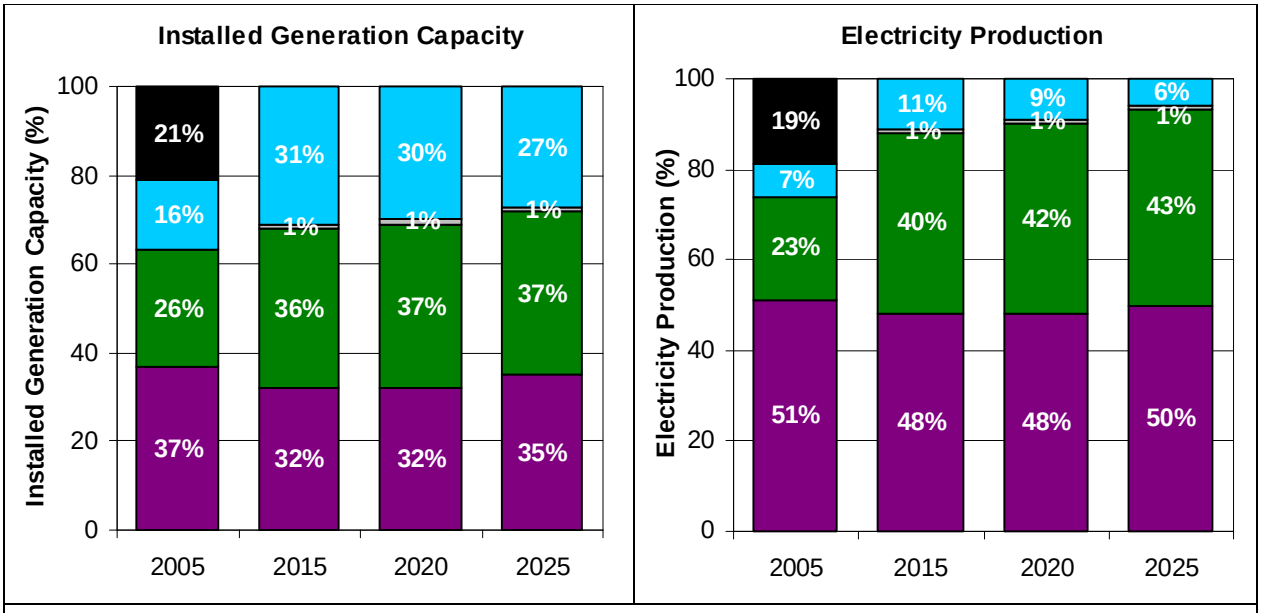
3. Gas-fired generation will play a targeted, but critical role:

- Gas-fired generation has a number of attractive features; it can be built quickly, can be located to relieve transmission bottlenecks, and can be used for district energy and cogeneration. It can complement wind generation in meeting demand, particularly in summer.
- The price of natural gas has increased four-fold in the past five years and is expected to remain high and volatile. Residential and commercial space heating and industrial processes compete for supply and several nearby jurisdictions also rely heavily on gas, all of which puts its availability at a premium or even at risk.
- Gas-fired generation is not recommended for base-load generation because in that role it

presents risks across all three dimensions of cost, environmental impact and financial risk.

Together, natural gas and renewable sources can replace coal generation.

Figure 1.1.4: Supply Mix Advice



(%)	2005	2015	2020	2025
Nuclear	37	32	32	35
Renewables	26	36	37	37
Gasification	0	1	1	1
Gas	16	31	30	27
Coal	21	0	0	0

(%)	2005 (Estimate)	2015	2020	2025
Nuclear	51	48	48	50
Renewables	23	40	42	43
Gasification	0	1	1	1
Gas	7	11	9	6
Coal	19	0	0	0

(MW)	2005	2015	2020	2025
Nuclear	11,397	11,000	12,000	15,000
Renewables	7,855	12,000	14,000	15,500
Gasification	0	125	250	250
Gas	4,976	10,500	11,000	11,000
Coal	6,434	0	0	0
Total	30,662	33,625	37,250	41,750

(TWh)	2005 (Estimate)	2015	2020	2025
Nuclear	79	76	81	89
Renewables	36	64	71	77
Gasification	0	2	2	2
Gas	11	17	15	11
Coal	29	0	0	0
Total	155	159	169	179

Source: OPA; Note: Figures shown take into account reduced demand due to conservation activities

4. Nuclear generation has a continuing role for base-load needs:

- The role of nuclear is not expected to change from its current contribution of 50% of electrical energy in Ontario
- Through their life cycle, our analysis shows that nuclear plants have less overall environmental impact than natural gas-fired generation and operate at lower cost for base-load needs.
- Changes in the Ontario electricity sector over the past few years make it possible to better manage the major risks of nuclear construction, which are cost overruns and delays.
- Significant progress has been achieved on the issue of spent nuclear fuel management.
- Refurbishing existing units, rebuilding on existing sites and undertaking "new build" plants can all contribute to maintaining the share of nuclear in Ontario's supply mix at roughly its current level.

5. Any plan must be flexible enough to act on new supply opportunities:

- Another technology that could provide base-load capacity at low environmental risk is gasification of a variety of fuels, such as municipal solid waste and coal, with containment of carbon dioxide.
- At present, this technology is not sufficiently developed to be relied upon for a major contribution, but the plan set out here has the flexibility to include it should it mature in future.

Many of the most attractive options for meeting base-load generation requirements entail long lead-times, so decisions need to be made quickly. Decisions must also be made with consideration for the longer term, because choices that focus only on immediate needs may foreclose more attractive options for the future. Figure 1.1.4 provides an overview of our recommendations to the Minister of Energy.

Conclusion

The advice in this report is intended to set Ontario on a course to:

- Maximize conservation and build on its potential in the future
- Pursue an aggressive course for renewables within current constraints, while looking at ways to reduce these constraints
- Adopt a "smart gas" strategy that takes advantage of the benefits of natural gas-fired generation but limits exposure to its price and supply risks
- Benefit from supply options that need long lead times, such as nuclear, large-scale wind generation, hydro imports and gasification

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1.2 Supply Mix Advice and Recommendations

1.2.1 First Step to an Integrated Plan

The supply mix advice in this report marks the first step in preparing an Integrated Power System Plan (IPSP) for Ontario, which will guide the development of Ontario's entire power system, including transmission networks. The first IPSP will be developed and submitted to the Ontario Energy Board (OEB) in 2006.

Through the *Electricity Restructuring Act*, passed in December 2004, the Government amended the *Electricity Act* to give the Ontario Power Authority accountability for preparing an integrated power system plan and vested the OEB with the power to approve it. This initiative was consistent with a recommendation of the Electricity Conservation and Supply Task Force that had reported in January 2004.

Both the advice in this report and the IPSP take a long-term view. To allow for changes in outlook, however, the integrated plan will be updated on a three-year cycle. This provides the process with the flexibility to reflect changing circumstances, take advantage of future opportunities and better deal with contingencies.

The supply mix advice looks forward over a 20-year horizon but must be considered as prescriptive only over the first three years of that period. A long-range forecast is inherently imprecise, since its assumptions will inevitably miss the mark to a greater or lesser degree. That said, a 20-year outlook is essential to identifying the need for immediate action, especially on important supply sources with long lead times. The advice in this report therefore looks at a range of scenarios, and emphasizes the immediate decisions needed to ensure that the most suitable longer-term options are opened up and preserved.

1.2.2 Challenges for Ontario's Electricity Supply

There has been a net decline in installed generating capacity in Ontario over the past 12 years, while the population has grown by 15% and the economy has grown by 45% over the same period. This is a major factor in the tight supply situation that exists today and the situation may grow worse in future. There are several reasons behind the decline in installed capacity. One was the halt of expansion due to an apparent over-capacity in the early 1990s, which remained as a supply overhang into the mid-1990s, while growth in demand was slow. Since then, investments have not kept up with retirements of existing facilities, especially in the GTA.

This is particularly true in base-load generation, where the last such investment decision was made in the early 1980s.

The age and condition of Ontario's nuclear fleet has also contributed to the current situation. Several units were taken out of service in the mid-1990s. While most have either returned to service or are expected to return, some will not.

Concerns about the environmental and health impacts of burning coal led to a government policy to replace coal-fired generation stations by 2009, with one station now already closed. The policy followed from the unanimous recommendation of an all party legislative committee in 2002. Reducing dependence on coal-fired generation has been reflected in the broad energy policies of successive governments.

On the demand side, moderation in demand growth has helped to shield Ontario until recently from lack of additional supply. The recent strengthening in the rate of demand in the past 5 years has eroded the excess supply capacity of the early 1990s. Looking ahead, Ontario's rate of growth in demand for electricity is projected to be steady but at a lower rate than it has ever been over a similar period in the last century. The potential impact of conservation and greater energy efficiency on demand growth is discussed in the section entitled "The Potential for Conservation."

There are several procurement initiatives under way that aim to close the supply gap in the mid term. As Figure 1.2.1 shows, these procurements would extend system capability to 2014 if they all materialize.

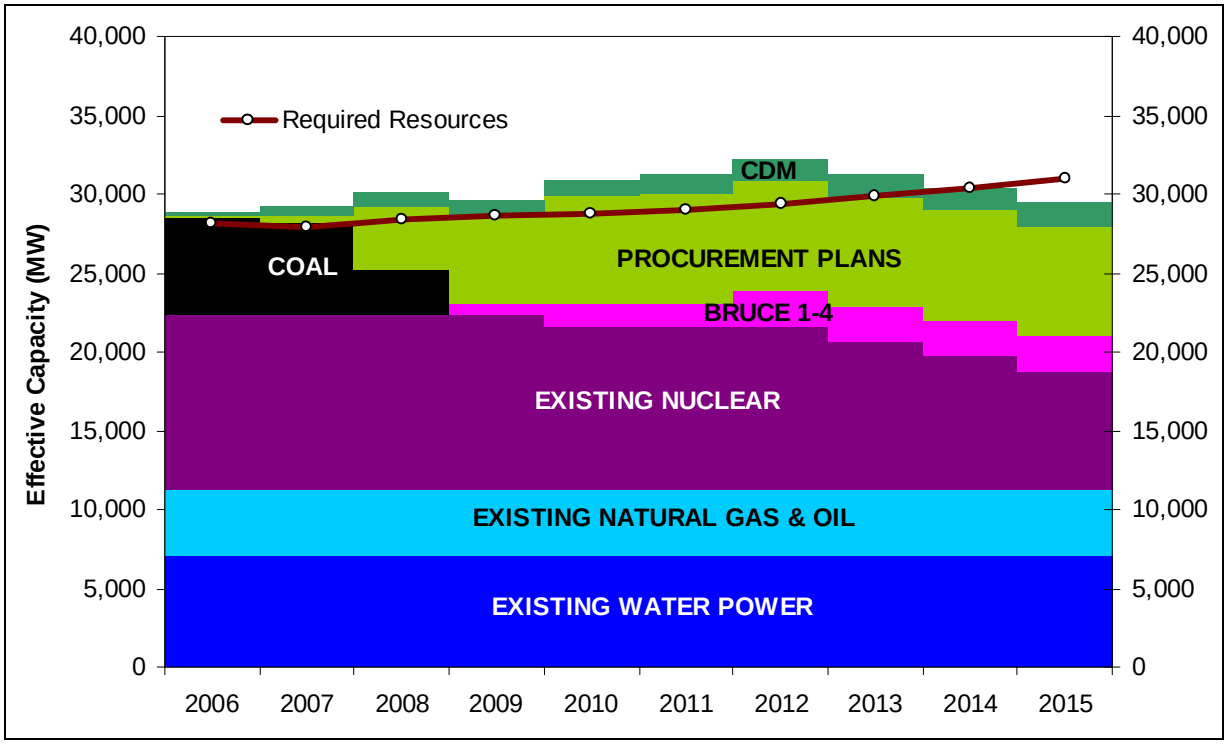
Figure 1.2.1 and many subsequent graphs show how the generation requirements are met by "effective capacity". The generation requirement is the amount required for summer conditions, under normal weather. The effective capacity describes the extent to which generating resources are available during the summer peak to meet the demand requirements. There are reductions from "installed capacity" – the nameplate rating of the generator – to arrive at effective capacity if the generator cannot be counted on to operate at full capacity during the summer peak. These reductions are most pronounced in waterpower and wind power.

Within the next 15 years, the nuclear units will be reaching the point where they must be either upgraded if they are to continue operating or taken out of service if this is not feasible or economical.

A focus for this report is therefore the period from 2014 to 2025 because this is not covered by current procurement initiatives. It is also the period during which the capacity of the nuclear generating units drops off significantly.

The purpose of the advice in this report is to build on current conditions and initiatives and look at the options for Ontario's supply mix out to 2025.

Figure 1.2.1: Current Procurement Initiatives and CDM Cover Needs to 2014



Source: OPA

1.2.3 Developing the Advice

The six principles set out in the summary – listening, sustainability, flexibility, embracing the future, managing risks and prudence – created a broad and well-defined set of criteria for solutions within the policy framework. These criteria took into account, on a full life-cycle basis, the overall cost of each supply option, the degree of financial risk it carried, and its general environmental impact. As combinations of options were developed, these were checked for reliability, feasibility and long-term flexibility.

The range of activities undertaken in developing this advice included:

- Consulting with Ontarians to determine their views and values about electricity planning, and to seek specific advice;
- Assessing the potential environmental, economic and reliability impacts of various supply sources and supply mixes;
- Refining and building on forecasts for electricity demand, and estimating the extent to which reducing demand and conserving electricity is achievable to help meet Ontario's needs;

- Assessing the risks, costs and benefits of possible supply mixes, to narrow down the suggested options to those that best align with the guiding principles, particularly prudence, and the request of the Minister; and
- Providing advice and setting out an action plan based on the above activities that, in our view, best responds to the Minister's request and lays a solid foundation on which to draw up the Integrated Power System Plan.

A task of this complexity could not have been completed without the specialized knowledge of expert consultants. A number of environmental, energy efficiency, planning, economic and public-opinion research firms made significant contributions. Volume 4 of this report includes all of their reports.

In developing this advice, a key step was to assess the views and concerns of people in Ontario, both citizens at large and those with a particular interest in the sector. A request for public submissions, as well as in-depth interviews and a broader survey conducted by Decision Partners with the assistance of Decima Research, yielded important information in these areas. Additional valuable contributions came from industry and environmental representatives and academic researchers who responded to requests for presentations in specific areas.

Together, the consultations revealed several important points:

- The vast majority of consumers in Ontario rank availability, reliability of supply and rate stability as highly important.
- The next most important concern among those interviewed or surveyed was environmental responsibility.
- Consumers and businesses place significant emphasis on the impact of supply choices on electricity prices and the provincial economy generally.
- Leadership, taking action, and looking at the long term in planning were all seen as important elements of moving forward.

In addition to these widely-expressed views, several industry and other participants with particular interests provided valuable thoughts and advice. An overview of all contributions is included in Part 2.3. The advice on specific initiatives for increasing conservation and getting more renewables, as well as addressing other industry issues, is included in Part 1.4.
We thank all those who took the time to provide their views and comments.

1.2.4 Estimating Demand

The annual electricity use in Ontario is currently running at about 155 terawatt-hours or TWh, which is a billion kilowatt hours. That is equivalent to every household in Ontario having fifty 100-watt light bulbs turned on 24 hours a day for the whole year. The forecasts for energy demand that extend to 2020 show demand in Ontario by that time ranging between 170-198

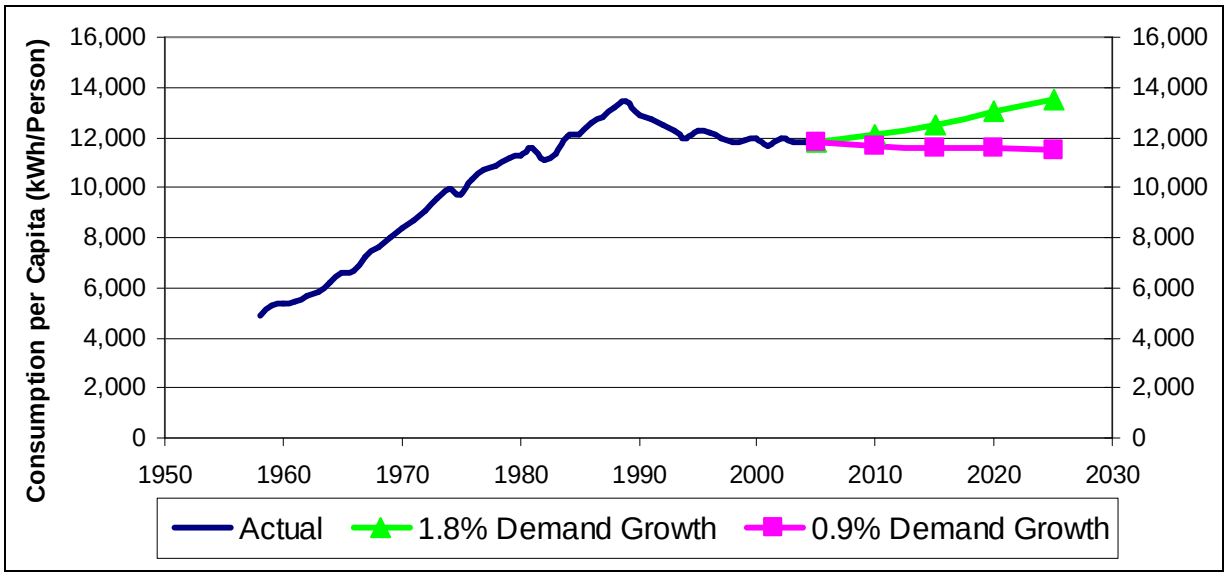
TWh. Section 2.5 provides more detail.

- Electricity use in the residential sector – the homes Ontarians live in – accounts for about 30% of total consumption and is projected to decline slightly.
- Highest electricity use is in what is collectively called the commercial sector – offices, shops, schools, warehouses, hospitals, hotels, etc. This sector accounts for over 40% of total electricity consumption today and is projected to grow the most.
- Industrial sector consumers use about 30% of the electricity consumed, and this is projected to stay about the same.

The variation in forecasts reflects differing assumptions about growth in Ontario's population and economy, as well as energy prices and technological improvements to equipment and appliances. For planning that includes conservation estimates, it is critical to know how much energy efficiency is assumed in any particular forecast. ICF Consulting helped to place electricity growth in the context of economic and demographic variables in developing this advice. Their report is included in Part 4.2.

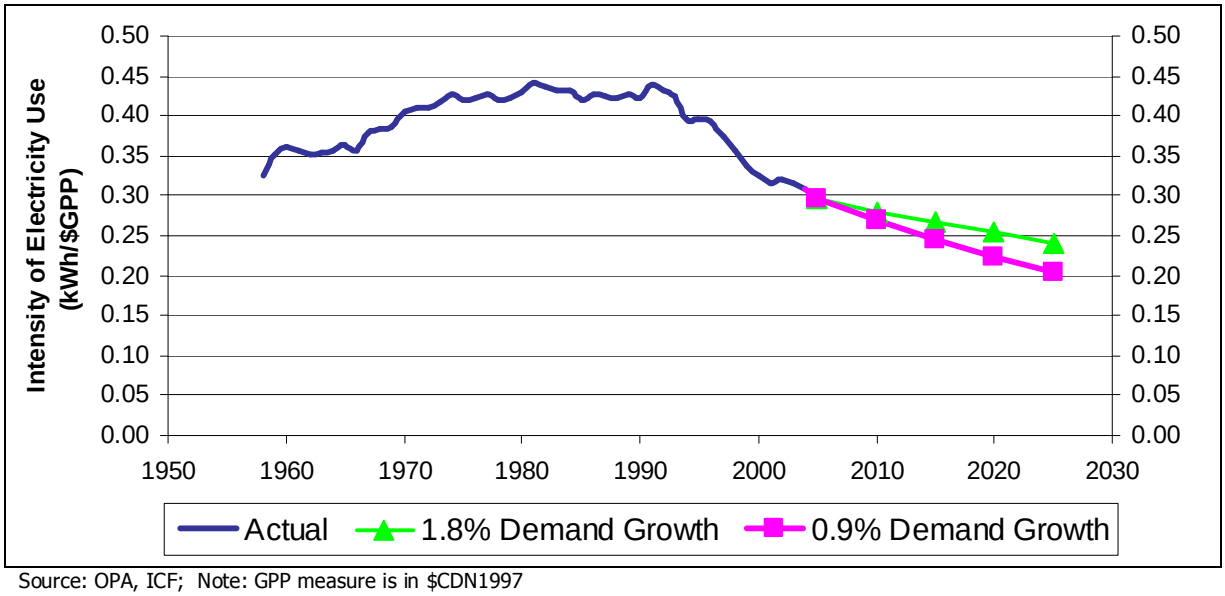
The graphs in Figures 1.2.2 and 1.2.3 show, for historical and forecast periods, two indicators of energy demand – how much electricity is used per capita, and the electricity intensity of the economy.

Figure 1.2.2: Ontario Electricity Consumption per Capita



Source: OPA, ICF

Figure 1.2.3: Ontario Electricity Intensity



Source: OPA, ICF; Note: GPP measure is in $CDN1997

The diverging lines show the impact of differing assumptions about load forecasts.

- Looking at per-capita consumption, the historical trend line shows an increase from the 1960s through to the 1980s but a drop since the early 1990s. Ontario's population is projected to increase by 25% by 2025, based on an average annual growth in population of 1.1%. A forecast of 0.9% a year growth in total demand therefore assumes that use per person will continue to fall in future. A forecast of 1.8% per year assumes an increase in use per person. Part 2.2 looks at Ontario's demographic context in more detail.
- Ontario's economy is projected to continue to grow at roughly 2.5% a year. In terms of electric intensity, the trend that began in the 1990s of using less electricity to produce each dollar of economic output is projected to continue.

In our view, the assumption of a lower rate of growth in electricity consumption is reasonable. This corresponds to an average annual rate of growth in energy demand of 0.9% and an energy demand of 185 TWh by 2025, up from 155 TWh in 2005.

It is important to bear in mind that these are broad measures of use. While overall growth is currently running at 0.9%, peak usage is growing faster. Peak demand is higher under extreme weather conditions – increasingly, the hottest summer days in Ontario. The planning assumption is that additional demand on extreme weather days will be met through interconnections with other jurisdictions and generation reserve margins that are required for reliability.

Based on the current average increase in peak of 1.3% a year, the corresponding demand for peak power demand under normal weather conditions would be 30,400 MW by 2025, up from

24,200 MW in 2005. Unless otherwise stated, "peak demand" refers to normal weather conditions.

There are local pockets of much higher growth in peak demand – for example, double or more the average in parts of the Greater Toronto Area. This has implications on reliability and adequacy of supply during peaks, which are becoming critical. Understanding why and where peak use is growing helps to focus on the need for conservation and demand management measures, as well as which supply facilities are needed most urgently. It also helps in identifying transmission needs, which the Integrated Power System Plan will address.

The Potential for Conservation

Reducing the use of electricity benefits individual consumers by lowering their bills, and the electricity system as a whole by limiting the need for new capacity. Smoothing the spikes of peak demand prolongs the usefulness of equipment and boosts the reliability of supply. Most importantly, conservation is the only way of balancing electricity demand and supply that has little or no long-term impact on the environment.

Conservation goes hand-in-hand with the related concepts of demand management, demand response and demand reduction. Conservation refers to a wide range of changes in behaviour and technology that result in lower demand for electricity. Demand management has an additional element, which is to change the timing of demand and reduce peaks through such means as demand response. Together, conservation and demand management (CDM) can reduce the supply capacity required to meet Ontario's needs.

The May 2004 report of the Province's Conservation Action Team recommended the appropriate scope for CDM in Ontario. It sees CDM as: energy efficiency, changes in behaviour or operations, such as the use of "smart" control systems, measures to better manage system load, for example by shifting demand to non-peak times, fuel switching and distributed generation, and higher standards for buildings, appliances and equipment, including cogeneration and back-up generation. For the purposes of this report, cogeneration is included under gas-fired resources.

In preparing the supply mix advice, the challenge was to examine how CDM might influence demand for electricity in future. This is a complicated exercise, because the starting point for the investigation was the base case load forecast. The forecast already includes assumptions about such factors as future gains in energy efficiency.

For the purposes of the supply mix advice, then, the focus was on estimating the potential for CDM beyond what is captured in the existing forecasts of demand. The rate at which energy efficiency increases across society depends on several factors, such as the age of existing equipment and appliances, the efficiency of newer models, the funds available to invest in

replacement, the preferences of purchasers, and the price of electricity. The rate of uptake can increase through measures that range from educational programs to providing additional economic incentives, all of which involve costs.

The consultant on this work, ICF Consulting, used a hybrid approach to producing a forecast of the additional drop in demand that would result from incentive programs to achieve greater energy efficiency. An "experience-based" element of the approach looked at the savings achieved elsewhere through such measures and applied those findings to Ontario. An "accounting-based" element looked at potential across the sectors that make up Ontario's economy to try to estimate total gains.

Unfortunately, a lack of detailed data for Ontario's electricity use limited the usefulness of both elements. In comparisons with other jurisdictions, it was impossible to know whether the assumed starting point for Ontario was the same. This same limitation, lack of detailed Ontario data, also made a sectoral approach challenging. As well, the long time horizon added to the uncertainty.

The work estimated the reduction expected by 2025 in peak use – that is, the situation that would occur on a hot summer day. The lower bound of the ICF estimates is 1,500 MW and the higher limit is 4,000 MW. On a more moderate day, the range would be roughly 1,050 MW to 3,600 MW. (The difference reflects that on the hottest days an air conditioner will operate for a longer time than it will on a moderate day, so that the reduction in energy use for a higher-efficiency unit is correspondingly bigger on hotter days.)

Because of the acknowledged difficulties in developing these figures, the ability to plan supply after accounting for conservation is challenging. The recommended supply mix chooses to rely on the lower set of figures for gains in energy efficiency because the risks of planning less supply far exceed the risk of not adjusting to higher conservation. These are planning assumptions and not the targets of the OPA's Conservation Bureau. Since we also explored a scenario at the upper limit of the estimate, the recommendations have the flexibility to accommodate higher successes in achieving conservation.

It is important to bear in mind that these savings are in addition to conservation gains already targeted for 2007. They would also be in addition to the impact of smart electricity meters, which are to be installed for every customer by 2010, and are estimated to reduce demand by 500 MW. Procurement initiatives under way are expected to yield a further 250 MW in demand management and demand response initiatives. In addition, 10 MW are already under contract.

The experience developing this forecast suggests that more work is needed to determine the full potential for conservation, its components, and the areas in which investments will provide the greatest return.

1.2.5 New Renewable Sources

Increasing the share of renewable energy resources in Ontario's electricity system can have significant advantages. Typically, these sources involve lower impact on the environment, provide more sustainable supply over the long term, and generally have predictable operating costs once the necessary infrastructure is put in place.

Ontario's current supply mix, in which large hydro developments provide about one-third of capacity, reflects a long-standing reliance on renewable sources. In recent years, new technologies and concerns about the environmental and economic costs of non-renewable sources have opened up a rich range of possibilities for new sources of renewable supply. To this end, developing this advice involved extensive analysis of such sources, including wind, additional hydro, biomass and photovoltaic, which is a form of solar generation.

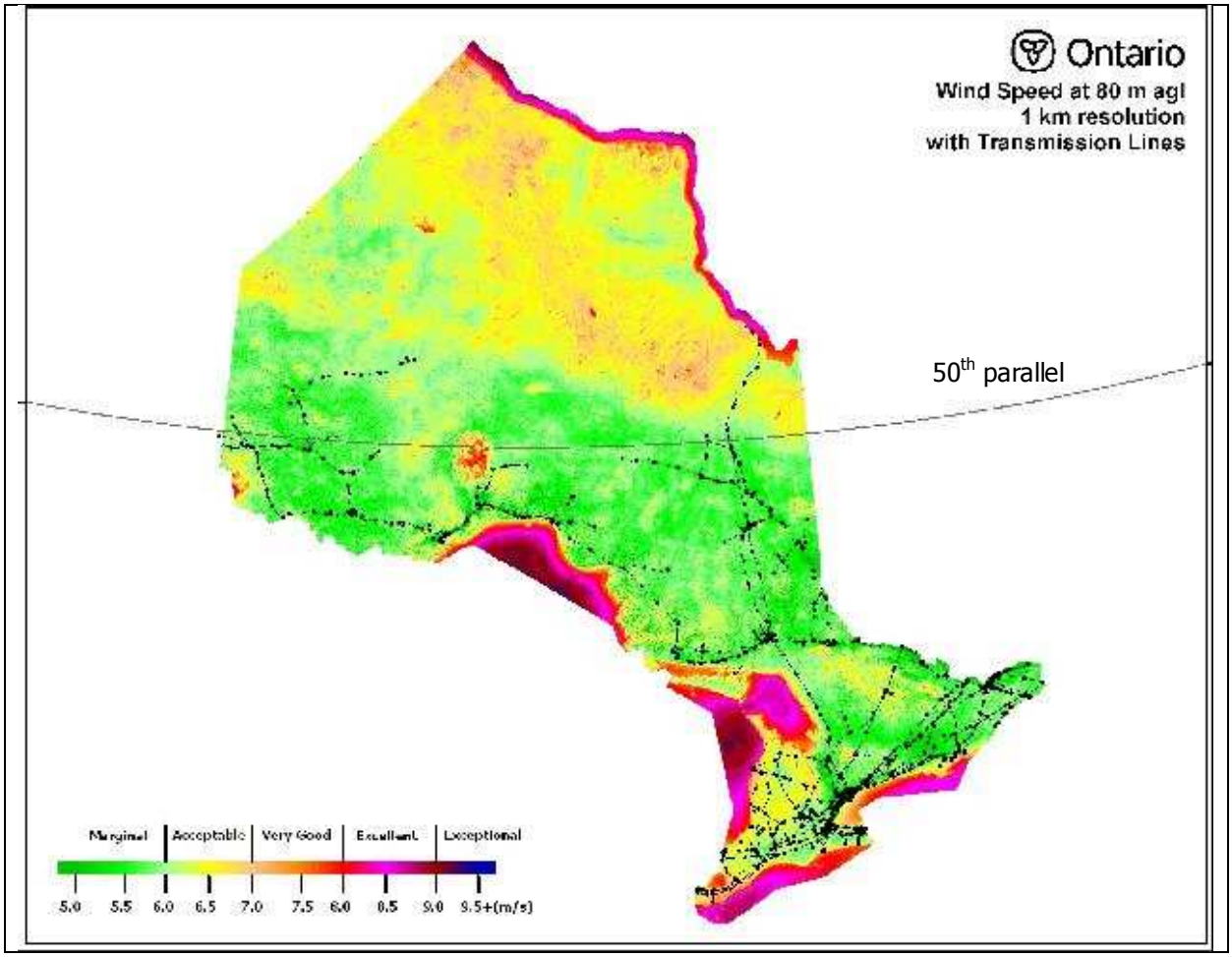
In addition to the summary provided here, Part 2.4 outlines the experience in other jurisdictions with developing renewable energy resources. Part 2.7 reviews the environmental and technical characteristics of renewables, Part 3.6 includes a background report on Ontario's potential for water resources and Part 4.5 contains a consulting report on Ontario's wind resources. Part 1.4 details the advice provided to OPA to obtain additional renewables.

It is important to keep in mind, when looking at potential renewable sources of electricity, that some of these technologies have not already been developed on a large scale because of significant challenges. The theoretical potential for renewable energy is typically large, but gets narrowed down by technical feasibility, then further by financial feasibility, and still further by social and environmental considerations.

Wind Power

The results of the analytical approach used to develop this advice show the extent to which wind power may have the potential to provide a considerable share of Ontario's energy needs by 2025. Helimax Energy of Montreal, a consultant to Hydro-Québec and the Canadian Wind Energy Association, provided much of the work in this area. The analysis involved merging data from the Ministry of Natural Resources' (MNRs) extensive and detailed Geographic Information Systems (GIS) on Ontario's wind resources with Hydro One Networks' GIS data on transmission and distribution. While the theoretical potential is vast – in the order of 600,000 MW, or roughly 20 times Ontario's current demand – the logistical and other constraints make it unrealistic to harvest all of this potential.

Figure 1.2.4: Ontario Wind Speed Map with Transmission Lines



Source: MNR

The constraints on developing wind power arise mainly from climate and geography. Wind power is generally considered to be economic only in those areas where the average annual velocity is greater than 6.5 metres per second at 80 metres above ground level (agl). Using MNR data and that threshold, Helimax determined the potential for wind generation capacity across Ontario as 630,000 MW, capable of producing 1,700 TWh of energy production annually. This estimate was based on removing areas with constraints, such as roads, parks and houses, and allowing for buffer areas. It did not, however, address local issues, such as land use regulations and social acceptability. It also did not address proximity to energy users.

One major obstacle to drawing on the potential is the distribution of areas of economic wind velocity: roughly 95% of the potential is located north of the 50th parallel of latitude, which lies above the northern-most stretches of the Trans-Canada Highway. This puts it effectively out of reach of Ontario's existing electric transmission system. There are significant engineering, environmental and economic issues to harvesting this wind, but further research should be done to better understand the challenge and opportunity. Looking at the land area south of the

50th parallel, however, there is still 29,000 MW of wind capacity and 79 TWh per year of wind energy production – a potential amounting to Ontario's current installed capacity, and about half of its energy consumption.

Table 1.2.1: Ontario Onshore Wind Potential

Area	MW*	TWh**
North of 50th Parallel	598,884	1,632
South of 50th Parallel	29,183	79
Entire Province	628,067	1,711

* Assumes 5 MW of capacity per suitable km^2 of area; ** Assumes 31.1% average net capacity

The question then becomes the distance from the best areas for wind development to the wires that deliver power to consumers. Cross-referencing the MNR data with Hydro One Networks' data showed that, south of the 50th parallel, there are roughly 7,000 MW of wind power within 10 kilometres (km) of high-voltage transmission lines.

If connected to the transmission network, this power would be available across the entire Ontario electrical syste`m. Almost 3,000 MW of power lies within 5 km of distribution stations. (See Part 4.6 for additional detail). This power, once connected to distribution networks, could be suitable as a resource for local customers, reducing the need for generation to be delivered to the area. These numbers are not additive, however, since some wind areas lay within both the 10-km distance to transmission and the 5km-distance to distribution. For this stage of the analysis, 7,000-9,000 MW potential was considered close to some part of the existing electricity system.

Three system planning and operation issues affect how much wind can be accommodated in Ontario's electricity system. Firstly, when considered as a resource to meet peak system demand, not all of wind's installed capacity can be considered available, because there may be times when demand is at peak levels and the wind is not blowing. The coincidence of wind and peak demand in the summer is only 10% or less, but is roughly 20% in winter. This is because wind speeds are higher and more consistent in winter, making wind generation better suited to meeting winter needs. Also, wind may be better for winter peaking needs than summer peaking needs because the days on which demand rises in winter are more likely to be windy.

Secondly, as the first point makes clear, wind is not a "dispatchable" resource. A dispatchable resource, such as a natural gas-fired generator, can increase energy production when called on to meet increased demand. Power from wind, in contrast, depends on the force of the wind. For reliable supply, dispatchable resources are needed to complement wind generation. A related issue is that there will be times when wind velocity drops, reducing supply from this source, but demand continues. Complementary resources that can be dispatched quickly are needed at those times.

Thirdly, even where wind resources are close to distribution or transmission lines, many of the lines and system equipment will need to be upgraded to accommodate the variability of power flows if wind power development is to be significantly increased.

These issues must be considered in planning for increased wind capacity, especially because of the economics involved, which currently make the price of wind power relatively high. Experience and studies from other jurisdictions, such as Alberta, California, Germany and New York, suggest that the costs and planning issues, especially related complementary supply, increase quickly after a certain threshold of reliance on wind in an integrated system. For this reason, an upper limit of 15% on the share of installed wind capacity in total supply appears to be a practical and reasonable assumption until there is more experience with integration of wind on an even larger scale.

In summary, there is potential for wind to become the major source of new renewable resources in Ontario. The greatest potential, in Ontario's north, will likely not be tapped within the time horizon of this advice. It is worth taking this into consideration if plans are developed for a transmission line for purchases from Manitoba, because the routing of this line could take into account the rich wind resources that lie between James Bay and the Manitoba-Ontario border.

Waterpower

Although Ontario developed most of its large waterpower or hydro sites early in the 20th century, many smaller sites still exist. MNR keeps data on these resources, and identifies 180 sites in Ontario with a technical potential of approximately 7,500 MW, including both new sites and improvements at existing sites. The new sites included in this technical potential are shown in Figure 1.2.5.

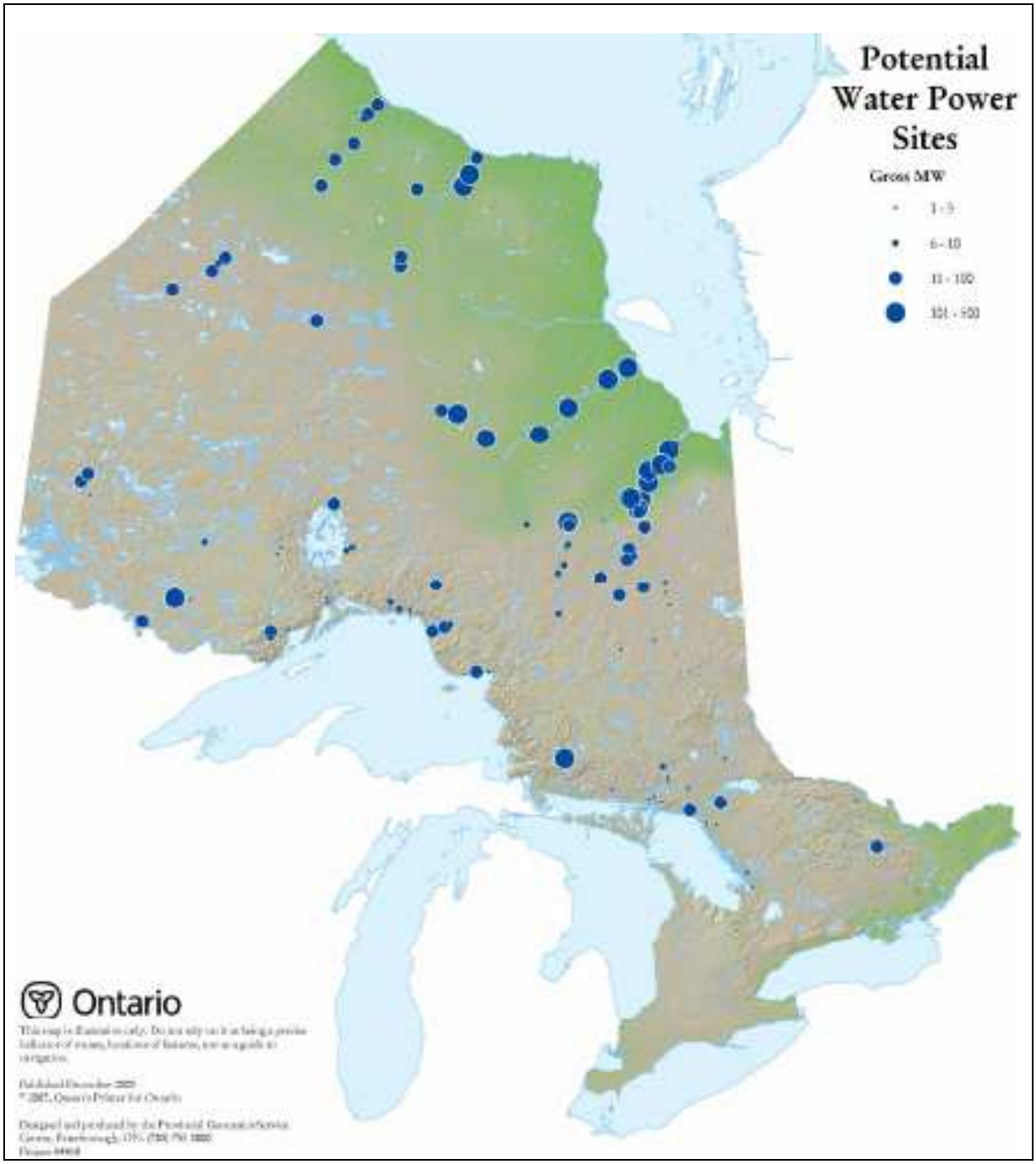
In line with the need to filter renewable sources for feasibility, OPA sought the assistance of MNR to screen the waterpower sites for policy impediments and other constraints such as tourism and other recreational use that would inhibit their development. Table 1.2.2 shows that there are roughly 1,500 MW in areas that are not protected from development.

Table 1.2.2: Ontario Potential for New Waterpower

Waterpower Categories	Total (MW)
Total Ontario Potential	7,585
Less: Parks and Conservation Reserves	(1,501)
Less: Subject to Agreements with First Nations and Fed. Gov't *	(4,637)
Remaining Potential for consideration at this stage	1,447

Source: OPA; *Moose River Basin and Northern Rivers

Figure 1.2.5: Ontario's Potential Waterpower Sites



Source : Ministry of Natural Resources

With the knowledge of the developable sites established, OPA worked with MNR and Hydro One Networks to determine the proximity of these sites to transmission and distribution systems. (While there are other transmitters and distributors in Ontario, Hydro One Networks'

data was considered sufficient for this preliminary exercise because it is the utility in most of the rural and northern areas where the waterpower sites are situated.)

Table 1.2.3 - Waterpower Potential within Policy Guidelines by Site Size and Proximity (MW)

Connection Proximity of Site	Under 1 MW (50 sites)	1– 5 MW (28 sites)	5-10 MW (12 sites)	10-100 MW (7 sites)	Above 100 MW (2 sites)	Total
Within 5 km		39	33	311	660	1,043
5-25 km		17	41	69	0	127
Beyond 25 km		40	20	187	0	247
Total:	30	96	94	567	660	1,447

Source: OPA, MNR

Table 1.2.3 shows that only a small portion of the 1,500 MW potential, roughly 250 MW, is more than 25 km from a transmission line or distribution station. Developing this more remote waterpower would require a closer look at the economics of connecting to the electricity grid. The total includes additional capacity resulting from extensions and upgrades of existing hydroelectric facilities as well as a pumped storage site. Additional thoughts on this appear in Section 3.6, which contains additional detail on the potential sites. More detailed studies will be required to determine the need and economics of pumped storage.

A portion of the existing waterpower capacity is used for peaking demand, while another portion is used for base load. The new additions are expected to be mostly "run-of-the-river," making them more suited to base-load service, but they are only well suited to play this role in winter, not in summer. The reason is that daily peaks last longer in summer than in winter and there are more constraints on operation in general, such as cottage use and environmental restrictions, in summer.

Waterpower is therefore more limited in its ability to meet peak demands in summer than in winter. Peak use in Ontario is shifting from winter to summer, as air conditioning use rises. There is the additional concern that global warming will reduce the energy output from current hydro facilities because of lower water levels. This advice takes into account the shift in peak and its impact on hydro in this role, as well as the potential lower production from current facilities.

Site-specific limitations on the potential for waterpower developments are the economics of such characteristics as water flow, head and distance from transmission, and environmental concerns around ponding and erosion.

Biomass

Ranges for biomass potential to generate electricity vary considerably, from a few hundred to several thousand megawatts. The largest share is theoretically in the forestry sector. The

potential is significantly reduced by two constraints – the limited availability of forest resources and the cost of collecting material and transporting it to generating plant locations. While there are agricultural opportunities for using crop residue and animal waste (biogas digesters), growing crops specifically for electricity production is unlikely to be viable.

Municipal solid waste gasification and gas from wastewater (sewage) treatment plants and landfill are other potential sources, although public acceptability has been an historic concern, largely due to the perception that producing energy from these sources must involve incineration. In the environmental assessment of biomass, it was assumed to be carbon dioxide neutral, meaning that over its life cycle it produces as much as it captures. The cost of producing electricity from waste is higher than for many other sources, but to the extent that biomass generation reduces municipal disposal costs, it should receive an offsetting credit.

Municipal solid waste landfill sites and wastewater plants generate methane that can be collected to generate electricity. There are several such sites in Ontario already. The amount of power produced this way is likely to be small relative to total needs, because of the limitations of waste quantities, but it has nonetheless been included in planning for supply mix purposes. It is worth promoting this source because methane, when it escapes into the environment, is a potent greenhouse gas.

Solar Photovoltaic

When sunlight hits a photovoltaic cell, electricity is produced. Such solar-generated power has the advantage of using a free resource, has modularity that makes it suitable for connecting close to the load, and has significant potential for technological improvement. The challenge of solar-powered generation is its environmental life-cycle impact. This impact is dominated by the process to manufacture the photovoltaic cells, which itself is energy-intensive and creates toxic by-products. The cost of electricity from photovoltaics is of more than $180/MWh, higher than all other sources examined.

The Canadian Solar Industries Association suggested a potential for up to 40 MW of photovoltaic electricity supply by 2010. European countries have offered a high purchase price for solar-generated electricity that accelerated its use, particularly in Germany and Austria.

1.2.6 Conventional Generation

Hydro Imports from Neighbours

Ontario has significant capacity of interconnections with other jurisdictions, totalling 4,000 MW. The larger share is with New York and Michigan, with less interconnection capacity to Quebec, Manitoba and Minnesota. Interconnections increase reliability and permit trade in electricity.

Our analysis relies on interconnections for meeting extreme weather conditions. In addition, interconnections make ongoing, large-scale imports possible.

While Ontario long ago developed its most feasible and accessible large waterpower sites, Manitoba and Newfoundland and Labrador still have waterpower resources that could be developed and the output sold to Ontario. There are opportunities for importing from the United States, as well, but these are based mainly on nuclear, natural gas or coal-fired generation.

The advantage of additional large waterpower is that it is a renewable energy resource. On the other hand, the distances from the sites to the load centres in Ontario are great, up to 2,500 km, and significant transmission connections would be needed, with attendant costs and electrical losses.

Agreements would have to be reached with suppliers of the generation resource and with First Nations and other parties on the economic development and land use issues around transmission. Negotiations for long-term imports are at an early stage. However, if the line from Manitoba were built, it could form part of a national east-west electricity grid bringing additional generation from western Canada. It also could be used to carry wind generation from the Hudson's Bay lowlands.

A wide range of purchase prices must be used as estimates, because negotiations are still at a very early stage. For this analysis, the planning assumption is $50 to $120 per MWh, as shown in Figure 1.2.9, which includes the transmission cost associated with delivering the imported power.

The value of a hydro import increases if it can be scheduled to meet intermediate load needs and operating requirements. There are considerable synergies possible if water can be stored where the power is generated, so that this supply can be coordinated with the use of Ontario's base-load facilities. Scenarios to include imports are therefore based on the possibility of negotiating an agreement that provides value and fit with Ontario's long-term need.

Nuclear Power

Nuclear power was introduced on a commercial scale into the Ontario system in the 1970s. It grew to supply more than half of Ontario's electricity in the 1990s and currently provides about 37% of Ontario's generation capacity and roughly 50% of Ontario's electrical energy production needs.

As noted earlier and in Part 2.6, Ontario's most critical need in the long term is for base-load supply. Nuclear power is particularly well suited to this role, owing to its low operating cost and lack of air emissions during operation.

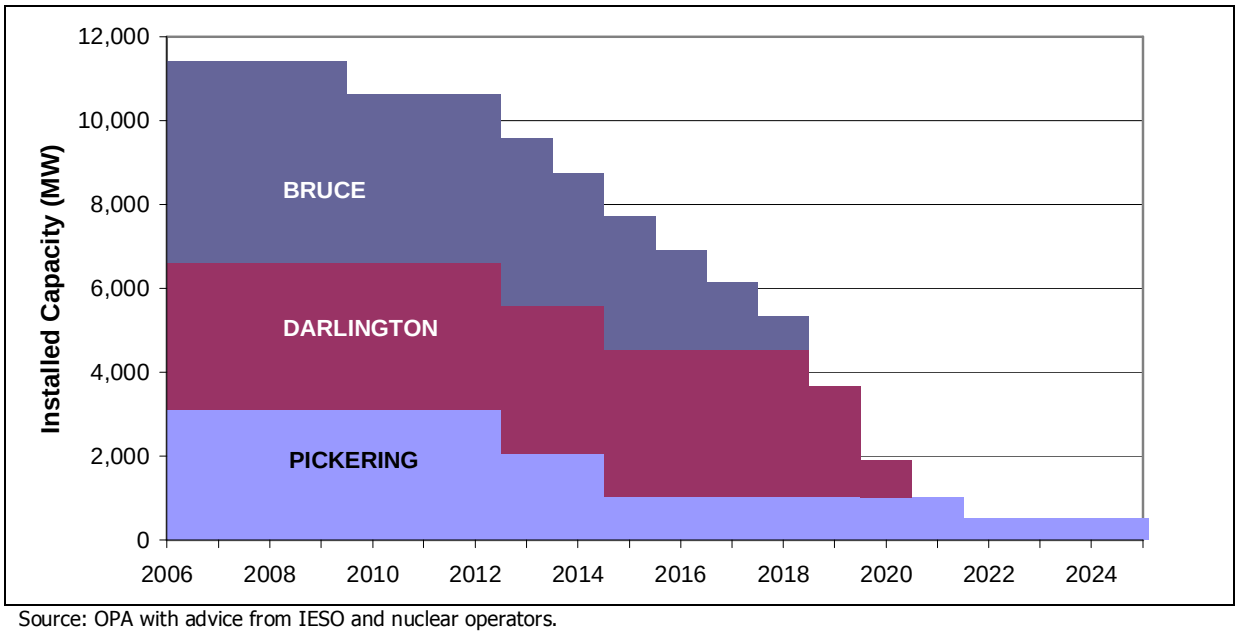
The environmental indicators show that nuclear energy has lower impact over its life cycle than many other supply sources, including natural gas generation. Storage of spent fuel is a critical part of a successful nuclear program. Considerable progress has been made in this area by the Nuclear Waste Management Organization, which issued its recommendations in November 2005. Part 3.7 reviews the recommendations in more detail.

However, nuclear energy in Ontario has faced many problems. There have been serious cost overruns on both initial construction and the refurbishing of older units. As well, it has been hard to achieve consistent operational excellence at some stations, which has reduced their cost advantage.

The mid-1990s marked the start of a particularly troubled period in the history of the nuclear fleet. Eight of Ontario's 20 units were taken out of service to focus attention on improving the performance of the remaining 12. Since then, a decision has been made not to restart two of the eight shut-down units, owing to the economics. Of the remaining six, four units have returned to service, with serious delays and cost overruns in one case, and contracts are in place to work on the remaining two, with a view to their ultimate return to service by 2009. By 2009, therefore, 18 out of 20 units are expected to be back in service.

Despite the returns to service, the fact remains that most of the current fleet was built in the 1970s and 80s. Figure 1.2.6 shows the potential points at which decisions would have to be made on extending the service life of units or taking them out of service:

Figure 1.2.6: Planning Assumptions Regarding Nuclear End-of-Service Dates



Source: OPA with advice from IESO and nuclear operators.

The decisions about how and whether aging units are to be refurbished or replaced are complex, calling for extensive assessment and coordination. In the case of refurbishment, the extent of the work may, in some cases, amount to essentially building most of a new unit in the place of the old one. This provides Ontario with the opportunity to take advantage of changes in nuclear technology that may be simpler to operate, cheaper to run and better performing. A number of options for new-build are possible; a further discussion is provided by Canadian Energy Research Institute (CERI) in Part 4.3.

It is also important to bear in mind that any nuclear work in Ontario, whether refurbishment or new-build, will be taking place in an environment that should allow much better management of the many concerns around such projects. Specifically:

- The corporate mandate and structure of Ontario Power Generation (OPG) and the involvement of private-sector capital have eliminated accounting and financing restrictions faced by the former Ontario Hydro that resulted in very large price increases when new plants it built went into service;
- Both OPG and Bruce Power, supported by capable supply, engineering and construction firms, now have considerably more experience in the successful management of nuclear projects;
- Access to international experience can contribute to a successful program in Ontario;
- New and more sophisticated approaches to financing major projects better allocate the risks among owner, operator, contractor, suppliers, customers and other parties; and
- Operational and performance audits and licensing processes will contribute to efficient operation and adherence to schedules.

At the same time, the long lead time for nuclear-related work presents special challenges, particularly given the large number of units that must enter into planning considerations. This makes it critical to decide soon what kind of work is to be done and when.

Another source of uncertainty is how well nuclear units, particularly those using new technology, will perform. Performance of nuclear units, which is measured by their "capacity factor," must be considered in supply mix advice, because it has implications both for the cost and the availability of nuclear supply. While it is impossible to predict accurately the performance of new technology, it is noteworthy that performance of most designs used world-wide and in the Ontario fleet has improved significantly in the last several years.

In summary, with construction and financial risk properly managed and if the nuclear fleet maintained high capacity factors and consistent operation, nuclear generation would provide an excellent alternative to the volatility of price and uncertainty of supply that are major drawbacks to gas-fired generation for base load.

If timely decisions enabled the nuclear generating options to be brought into service over a

relatively short period of time, this would provide the added advantage of reducing further exposure to the risks associated with natural gas-fired generation.

Natural Gas-fired Generation

Natural gas is widely used for electricity generation. Ontario already has about 2,800 MW of natural gas-fired generation and another 2,100 MW of dual fuel oil-gas capacity at OPG's Lennox generating station. For the past 15 years, natural gas has been the fuel of choice for new generation projects in the United States.

The price of gas in the long-term, however, is linked to the price of oil and as such is highly volatile. Oil's price varies with geopolitical events and the ever-increasing global demand. The advent of increasing supply in the form of liquefied natural gas (LNG) to North America opens up the option of transporting natural gas by ship, making it a global commodity like oil.

The price of natural gas has increased sharply over the past five years – from $2 to $3 per million BTU to the current $12 to $14, reflecting increasing global demand for oil and gas and, more recently, the impact of Hurricane Katrina. Natural gas-fired generation had a cost advantage in the 1990s, based mainly on its relatively low capital and fuel costs, but today the fuel price has pushed up operating costs to eliminate that advantage.

The combination of rising natural gas prices and a market for natural gas that is very mature and liquid increases the likelihood that operators of natural gas-fired stations may choose to shut down generation to free up the gas fuel for more profitable resale in the gas markets. Since gas and electricity demand peaks tend to coincide in cold climates, this phenomenon increases both price and supply risks for many systems with a heavy reliance on natural gas. This has become evident in such regions as New England.

The other major issue is the impact a large commitment to natural gas-fired generation has on capacity for gas infrastructure and deliverability in Ontario, and the effect this could have on the cost of gas used for other purposes, including residential and commercial heating and industrial process use. The impact of a rapid adoption of natural gas-fired generation in Ontario for power generation is also becoming a concern for neighbouring jurisdictions.

Among emerging technologies, natural gas fuel cells show promise because of their potential to create electricity directly from the gas, similar to a battery's operation, with low environmental impact. While they promise to be quieter and more efficient than conventional natural gas-fired generation, as well as being modular, like photovoltaic generation, they are still in the development stage.

Gasification

Gasification converts a fuel source, such as municipal waste or coal, to a gas and then generates electricity from combustion products, in a way similar to natural gas. The advantages of gasification are the lower emissions than from burning the fuel directly and the lower price volatility of various possible fuels, including coal, when compared to natural gas.

A potential longer-term enhancement to gasification is carbon dioxide sequestration, a process that captures carbon dioxide from the combustion process and contains it in long-term storage, such as under an oil well head. The cost for gasification with sequestration is high, estimated at $80-95 per MWh. As discussed in the biomass section above, biomass such as municipal waste can also be used as feedstock in gasification.

The most significant challenge for gasification is the lack of larger-scale experience by utilities with Integrated Gasification Combined Cycle (IGCC) plants. Processes similar to gasification have been used to produce liquid fuels in South Africa for many years, and are used in the chemical and petro-chemical industries. While there are a handful of plants around the world, IGCC is not yet a widely-used technology for electricity generation.

Owing to the abundance of coal in North America and the rising concern over energy self-sufficiency in the United States, energy policy in other jurisdictions is likely to feature massive research and development programs in coal gasification for many years to come, activity from which Ontario can benefit.

Gasification of coal without carbon dioxide sequestration has the highest environmental loading of all technologies considered. With sequestration, its environmental loading is still higher than nuclear or biomass, the latter of which is deemed to be carbon dioxide neutral. While gasification with sequestration is not considered feasible at this time, this may change over the next 20 years and gasification could therefore make an appearance in Ontario's electricity supply mix in the future.

Given that potential and the location of existing coal-fired stations near both coal-handling and electrical transmission facilities, it would be useful to preserve the coal-handling facilities after these plants are shut down.

Coal-fired Generation

As noted, the replacement of conventional coal-fired generation in Ontario has been adopted as policy by the Government. Coal-fired generation is a significant part of the present supply mix and managing its timely replacement has an impact on future supply choices.

While coal replacement is not the focus of this report, its relevance relates to the nature of the replacement alternatives in the supply mix in the long-term. The current schedule relies on a number of elements falling into place in the relatively short period before coal-fired generation is replaced. Firstly, the procurement initiatives for replacement of supply capacity, which are the result of Government directives to the OPA, would need to materialize fully. Secondly, demand would need to remain essentially flat through intensive conservation efforts. Thirdly, major transmission investments and reconfigurations to bring new generation into the grid would have to be completed.

While it is impossible to quantify all of the risks at this point, the price and supply risk around gas as a generation source has grown significantly. Early indications from projects now at the siting stage suggest that, to meet the goal of reliability, officials involved in the approvals process would need to recognize and respond more clearly to the priorities arising from that goal.

Given a relatively small supply margin, as shown in Figure 1.2.14, and the relatively large combined risk of the many elements on which supply reliability depends, the replacement of the coal-fired plants needs to be monitored closely for circumstances that may require the development of alternatives.

One of the scenarios considered in this report looked at this case. The conclusion is that it would make sense to continue monitoring the timing risks around the current schedule.

1.2.7 Balancing the Options

Planning supply mix would be simple if a single resource were superior to others in all areas – environmental impact, reliability and costs – and could meet equally well the needs of base, intermediate and peak load. Because no such single resource exists, a combination of resources and technologies is needed, and tradeoffs and synergies among them must be considered. In developing this advice, it was considered critical to take into account the environmental, economic and social impact of the possible combinations.

At this stage, the analysis looked at the broad picture. Therefore, without knowing siting and technology specifics, indicators of environmental impact, cost and reliability must, of necessity, be fairly broad. These indicators will be refined and become more specific for the Integrated Power System Plan. They will be more specific still at the stage when projects are being developed.

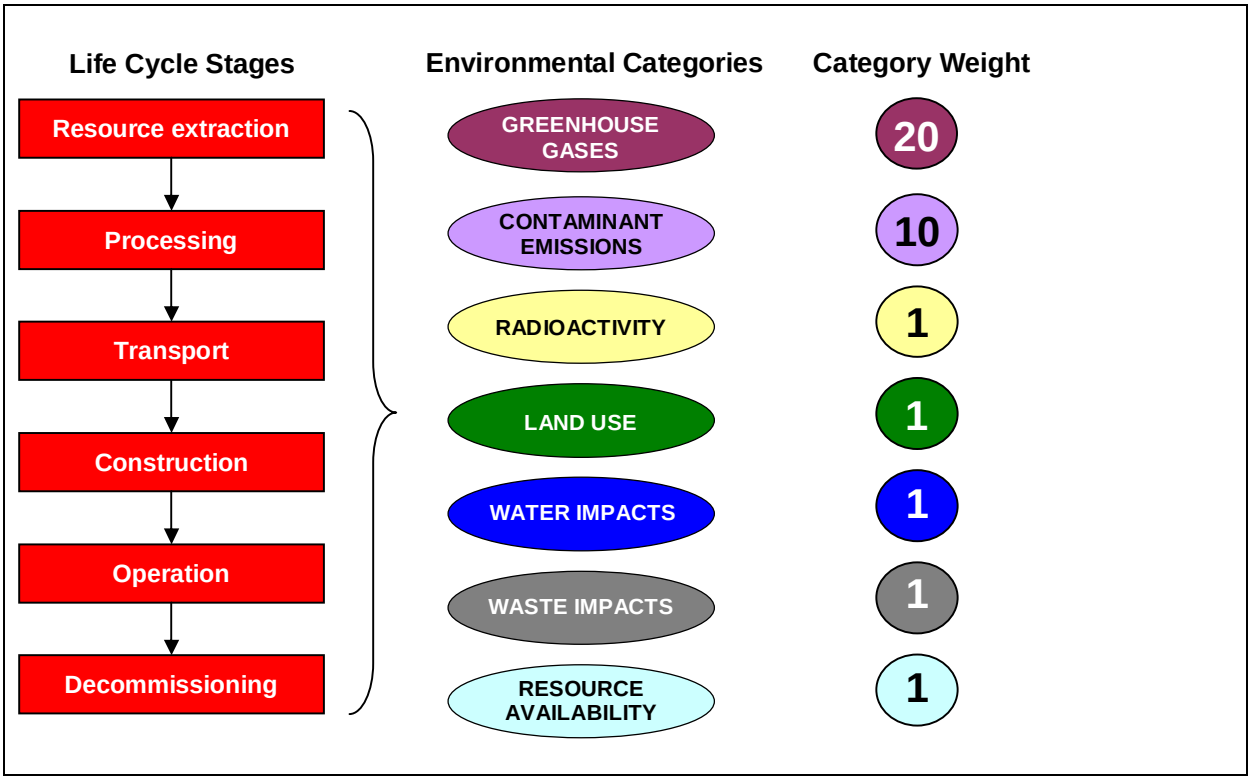
Environmental Impact

A "life-cycle" approach is valuable in weighing the environmental impacts of various supply

sources and potential supply mixes. This approach looks at the environmental impact of all the stages of the life cycle of a supply source: resource extraction, processing, transport, construction, operation, and decommissioning. It evaluates each stage and estimates a life-cycle impact.

To allow comparisons, the analysis groups the environmental impacts of various supply sources into seven categories: greenhouse gases (GHGs), contaminant emissions, radioactivity, land, water, waste, and resource availability, as shown in Figure 1.2.7. The method produces both absolute and relative scores of impact. The latter are more helpful when comparing supply options.

Figure 1.2.7: Life Cycle Environmental Analysis for Generation Options



Source: SENES and OPA

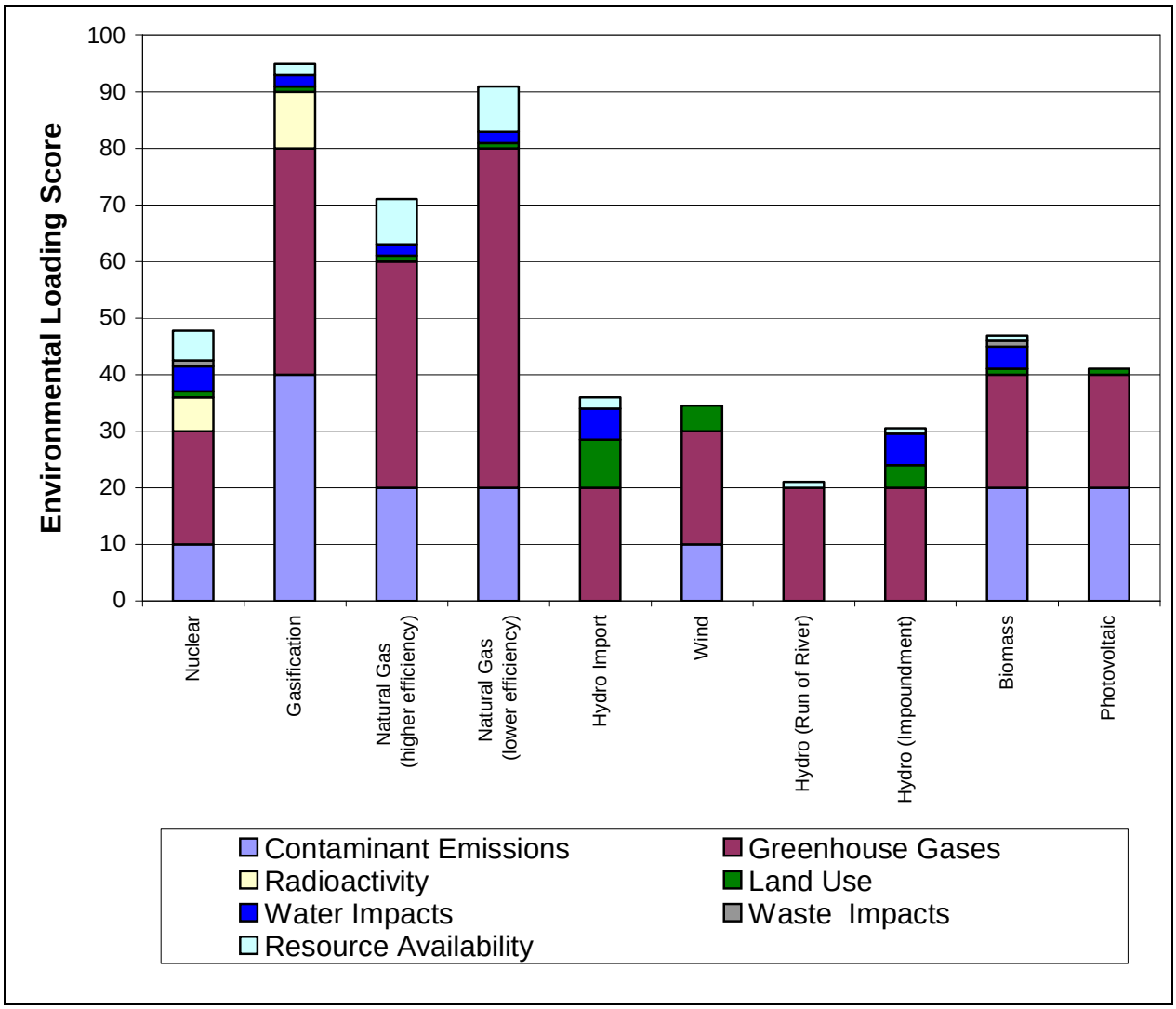
The consultant carrying out this work was SENES Consultants. In the other volumes, Part 4.4 provides their full report, while Part 2.6 reviews technical and environmental considerations together, and Part 3.2 provides a background report on how power system planning takes environmental sustainability into account.

SENES provided a raw score, by technology choice, for the life-cycle environmental impact of each generation technology on each category. A technology with no impact on a category was assigned a score of 0, while the worst performing technology in that category rated a 10. To

determine the total environmental loading score for a given technology, the relative weight of each environmental category must first be determined.

SENES recommended a weighting scheme based on the European Commission's exhaustive study of the life-cycle impacts of different generation options. It is considered a robust and well-researched study. In particular, the recommended weights were based on the monetized environmental impacts in France and the Netherlands. Section 4.4 contains more background on the work by SENES and the ExternE methodology.

Figure 1.2.8: Environmental Impact of Various Generation Options



Source: SENES and OPA; Notes: Gasification includes sequestration of carbon dioxide; biomass is carbon dioxide neutral

Adopting the SENES recommendation involved multiplying the raw score in each category –

greenhouse gases, contaminant emissions, radioactivity, land, water, waste and resource availability – by weights that reflected the relative environmental impact of each category. These weights are identified in Figure 1.2.7.

By adding the weighted score in each category together, a total environmental score for each technology choice can be calculated to give an indication of its total environmental loading. This aims to allow for meaningful comparisons of the environmental impacts of the different options.

It should be noted that the relative impacts of the various supply sources are highly sensitive to the weighting assumed for each factor. For example, greenhouse gases were given twice the weight of contaminant emissions, which assumes that their environmental impacts are twice as large.

The ranking of composite scores has produced some clear results. As Figure 1.2.8 shows:

- "Run-of-the-river" waterpower has the lowest impact on the environment, and waterpower generally has a favourable score
- Other renewables, particularly wind, also have relatively low impact
- Nuclear ranks at a level similar to biomass
- Technologies that burn fossil fuels have the greatest environmental impact
- Coal is actually responsible for higher radioactivity impacts than is nuclear – primarily due to release of radon gas in mining coal (see gasification results in Figure 1.2.8)

While not reported in Figure 1.2.8, the environmental loading score of conventional coal-fired generation is 216.5, approximately triple that of higher-efficiency natural gas-fired generation.

Relative Costs

The price of electricity clearly has an impact on consumers. For this project, CERI (Canadian Energy Research Institute) of Calgary undertook an evaluation of various supply technologies, resources and associated costs and risks from an economic perspective. The CERI report, which appears in Part 4.3, provides quantitative information on cost estimates, which we supplemented with updates and additional research.

The levelized unit energy cost (LUEC), expressed in dollars per megawatt-hour (MWh), is the most common way of comparing the life-cycle costs of different supply sources. It measures the direct costs of supply, not broader economic impacts such as job creation and other multiplier effects, nor the societal costs of environmental impairment.

The LUEC represents the constant amount of money that must be charged for each unit of electricity generated over the life of the supply source to recover exactly all life-cycle costs.

These would include the cost of construction, capital modifications, operating costs including fuel and its disposal, the cost of decommissioning, and the cost of capital. It can be thought of, not unlike a mortgage payment, as the amount that investors / consumers pay each year to retire the cost of a project over the life of the facility.

Risk adjusted cost of capital, or alternatively the discount rate used to determine present value costs and energy production, has an impact on the LUEC. It is generally accepted that equity investors require a higher return than do debt lenders. This means that the higher the share of equity in the capital structure, the greater the future cash flows must be. A higher equity share is reflected in a higher weighted average cost of capital (WACC) and, a higher discount rate in calculating the LUEC, all other factors being equal, results in a higher LUEC.

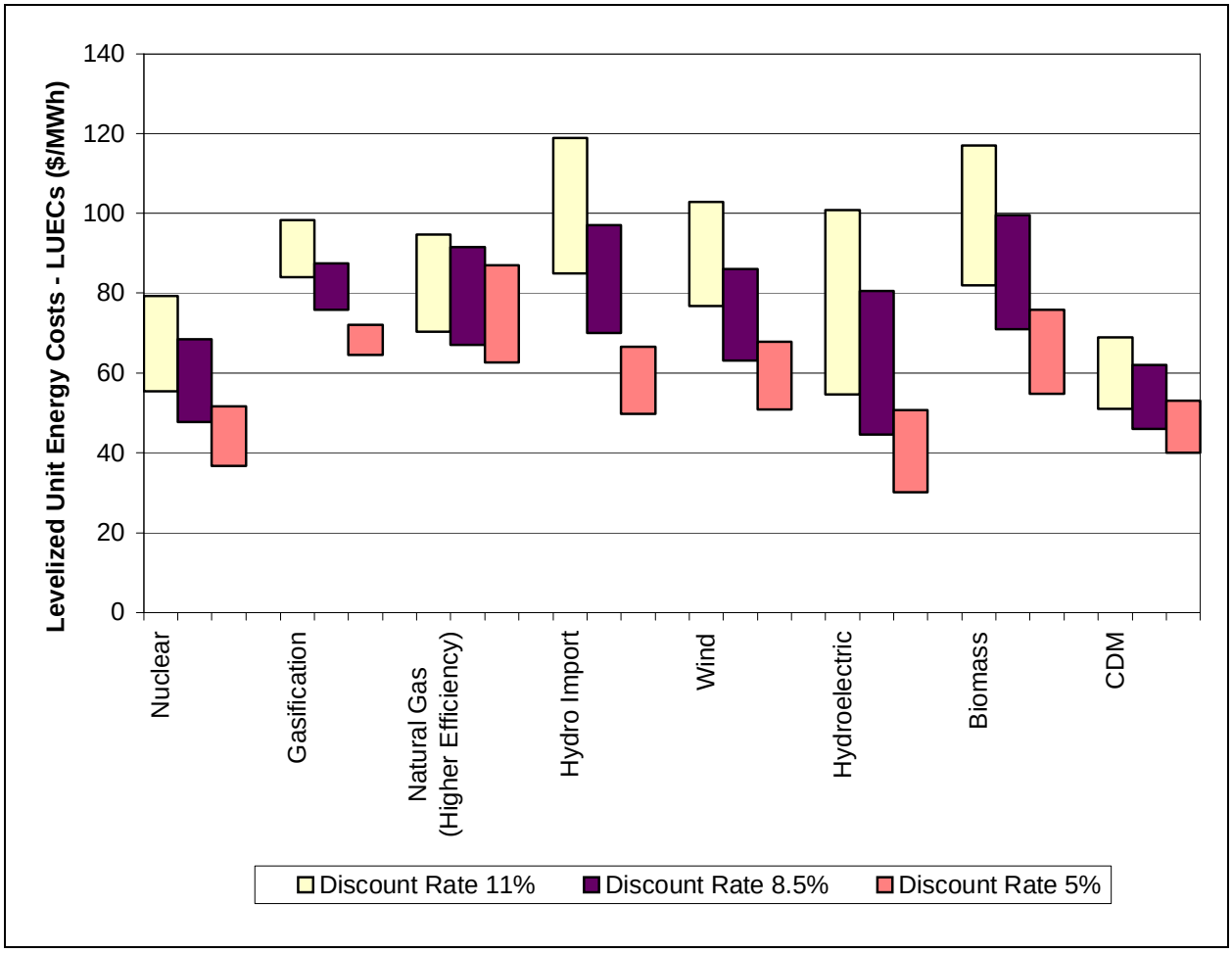
The impact on levelized costs of considering a range of discount rates is shown in Figure 1.2.9, which compares options under three assumptions – 5%, 8.5% and 11%.

In evaluating alternative generation options it is necessary to combine costs incurred throughout the complete life cycle of the various alternatives. Some costs are capital costs for initial construction and final decommissioning. These are large expenses at discrete points in time which must be combined with operating costs for maintenance and fuel. These are costs which occur continuously. Some generation options such as hydroelectric have high capital costs with low operating costs while others such as gas-fired plants have relatively low capital costs with high operating costs.

To compare all options on a common basis, the life cycle costs are reduced to a single "net present value" (NPV) by discounting costs from they time they are incurred in the future back to the present time. The discount rate used affects the relative attractiveness of plants with different ratios of capital to operating costs. A discount rate of 5% has been used in preparing the levelized unit energy costs (LUECs) for the supply mix advice. This rate is often referred to as a "social discount rate" and reflects the timescale over which electricity infrastructure contributes value to society. It is equivalent to the long term cost of public debt. In contrast a "commercial discount rate", which might be double the social discount rate, reflects the return on capital required by investors who are absorbing all the risks of developing, financing, owning and operating infrastructure. This approach of comparing LUECs based on a social discount rate is used in other jurisdictions.

CERI provided performance and cost characteristics for a number of specific generation technologies, together with updates and other data, which formed the basis of the graphs in Figures 1.2.9 to 1.2.11. LUECs are most useful for comparison purposes when the supply sources will fill the same role in the electricity mix. Figure 1.2.9 shows the LUECs for a range of generating options. Some are assumed to be operating to meet base-load needs, such as nuclear, natural gas and gasification. Others have their own operating characteristics dictated by resource availability, such as hydroelectric and wind. Part 2.6 provides detailed assumptions, calculations and sensitivity analysis.

Figure 1.2.9: Cost of Generation Options

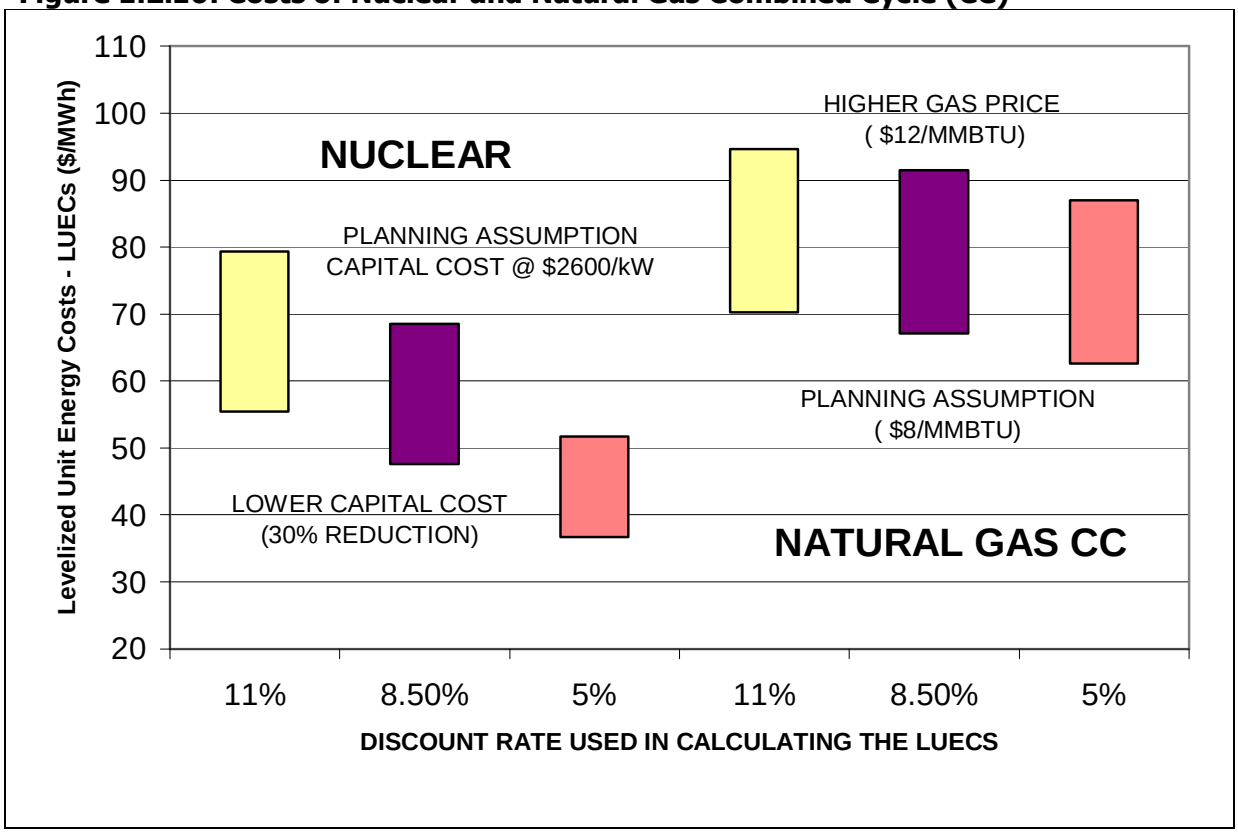


Source: OPA and CERI

Figure 1.2.10 is of particular interest, given Ontario's long-term needs, because it compares the costs of nuclear and gas-fired generation as base-load options. Gas and nuclear are reasonable candidates for meeting the balance of Ontario's needs in this area after conservation and new renewable supply sources have been factored in. LUECs for natural gas and nuclear options have been calculated under three discount rate assumptions – 5%, 8.5% and 11%.

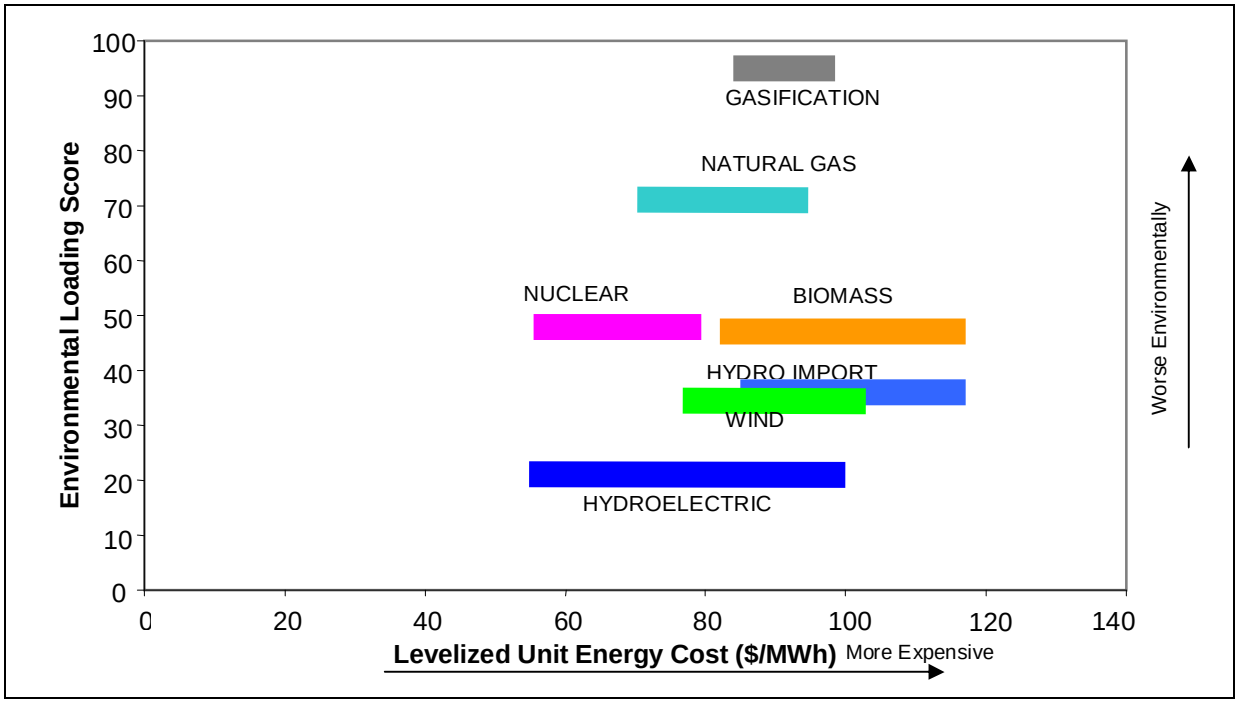
Figure 1.2.10 highlights that gas is much more likely to be a more expensive option for base-load needs. Under most discount assumptions, it would also be much less predictable in terms of costs over the long term, owing to gas price fluctuations.

Figure 1.2.10: Costs of Nuclear and Natural Gas Combined Cycle (CC)



Source: OPA and CERI; Note: Based on 85% Average Capacity Factor

Figure 1.2.11: Combined Environmental Impacts and Cost Ranges – Base Load



Source: OPA, CERI and SENES; Note: Levelized Cost based on 11% discount rate.

Considering Both Costs and Environmental Impact

The graph in Figure 1.2.11 combines the estimates of environmental impact with the LUECs from the preceding section. The closer a supply source is to the lower left-hand corner of the graph, the better it is from both an environmental and cost perspective.

Social Impact

The social impact of choices for the electrical system depends on the values of society. Public opinion research conducted for the supply mix advice showed that in Ontario, as elsewhere, reliability of supply is the most important concern. The key measure of social impact at this stage of planning, therefore, is whether electricity supply provided by the recommended mix will be reliable. Other broad concerns, including price and acceptability, also come into play.

Reliability has two dimensions – adequacy and security. Adequacy relates to confidence that there is enough capacity to meet needs. Security relates to confidence that power can be delivered to customers without interruption. This report, in providing advice about supply mix, is appropriately focused initially on adequacy. While security of supply is important, it also involves the distribution and transmission networks. It is therefore appropriate to consider this aspect further when developing the Integrated Power System Plan.

An additional concern for customers is price. To some extent this is covered in the discussion of relative cost above. For many consumers, however, it is not just the level of prices but the rate at which they change that is a concern. Ways to protect against significant changes include creating a diversified portfolio of supply sources and ensuring that a significant share of electricity comes from supply sources with low and stable operating costs. In addition, there are customers who are particularly affected by higher electricity rates, including low-income individuals and electricity-intensive industries. Specific measures, such as conservation and cogeneration, are needed to deal with the impact on these customers.

Finally, there is the important element of social impact that is specific to each proposed generating project: local acceptability. These issues tend to arise around specific projects and therefore cannot be adequately addressed in the more general averages that underpin analysis of supply mix. It is worth noting, however, that policies weighted toward overall provincial needs and priorities, in addition to those responding to local needs, can go a long way in reducing risks to electricity supply and reliability.

Table 1.2.4: Advantages and Challenges of Available Resources

Resource	Advantages	Challenges
Conservation and Demand Management	Low environmental impact, reduces energy and resource requirements, can be lower cost than generation, high potential	Relies on public uptake and behaviour, uncertainty around full extent of potential, and timing of adoption and implementation
Wind	Renewable, high availability of wind resource, low marginal cost, low environmental impact, coincident with winter peak, potential for cost reduction	Site feasibility limited by transmission access, intermittent, non-dispatchable, not coincident with daily summer peak
Waterpower	Renewable, low marginal cost, mature technology, low-medium environmental impact, ability to provide base-load, peaking/intermediate service	Site feasibility limited by transmission access and restrictions on use, greater new site availability for small waterpower than large waterpower, constraints on water use during summer peak
Biomass	Renewable, amenable to distributed and combined heat and power applications, amenable to landfill gas and municipal solid waste and wastewater applications	Potential constraints on fuel availability, economic feasibility, and local acceptance, medium environmental impact among renewables
Photovoltaic	Renewable, high availability of solar resource, coincident with summer peak, amenable to distributed applications, potential for cost reduction	High cost, intermittent, medium environmental impact from production and waste
Nuclear	Low operating cost, suitable for base-load service, potential for improved performance and cost reduction	Limited load-following capability, high capital cost, construction cost risk, long development and construction lead-times, complex waste disposal, public acceptance
Natural Gas	Fast construction lead-time, ability to provide load-following and peaking service, can be located to relieve transmission bottlenecks	Fuel price and volatility risk, higher environmental impact, potential for constraints on fuel deliverability
Gasification	Lower emissions than from burning fuel directly, lower fuel price volatility than natural gas, potential for carbon dioxide sequestration, potential for improved performance and cost reduction	Use of technology not yet widespread, uncertainty about operating performance and cost, potential constraints on site availability for carbon dioxide sequestration

Source: OPA

1.2.8 Developing the Appropriate Mix

Clear directions emerge from looking at the environmental impacts and costs of potential supply sources, as well as their reliability, feasibility and relative price stability. Harvesting full conservation potential, developing feasible renewables, managing exposure to natural gas prices, and protecting base-load capacity through refurbishing or building new nuclear units:

these are all strong footings for robust recommendations on supply mix. The next step is to look at combinations of the options to develop a sense of the total costs, benefits and risks of various strategies.

Starting Assumptions

The starting point for a long-term strategy on supply mix is the existing situation, life expectancy of each existing component, assessment of future growth, and upcoming changes that are reasonably certain because of procurements, policy directions, contracts and other arrangements already in place.
These were the starting assumptions:

Load Forecast:

Two sets of assumptions were explored, as represented in Table 1.2.5. Forecast 1, the planning assumption, is a moderate growth case. Forecast 2 assumes higher growth.

Table 1.2.5: Load Forecast Planning Assumption and Higher Growth Forecast

Forecasts for 2025	Peak Demand		Energy Production	
	Growth Rate %	Peak Demand (MW)	Growth Rate %	Energy Demand (TWh)
2005 Demand	--	24,200	--	155
Forecast 1 (Planning Assumption)	1.3	30,400	0.9	185
Forecast 2 (Higher Growth)	2.15	36,000	1.8	220

Source: OPA

Existing Resources that Remain in 2025:

It is assumed that 12,000 MW of effective capacity associated with the current generating capacity will remain in service in 2025. This is made up of hydroelectric, oil and gas, and one unit of Pickering A nuclear station.

Procurement Initiatives and Assumptions:

Procurement activities already under way or completed will add to the existing generating capacity and CDM potential. These are identified in Tables 1.2.6 and 1.2.7.

Table 1.2.6: Procurement Initiatives and Assumptions

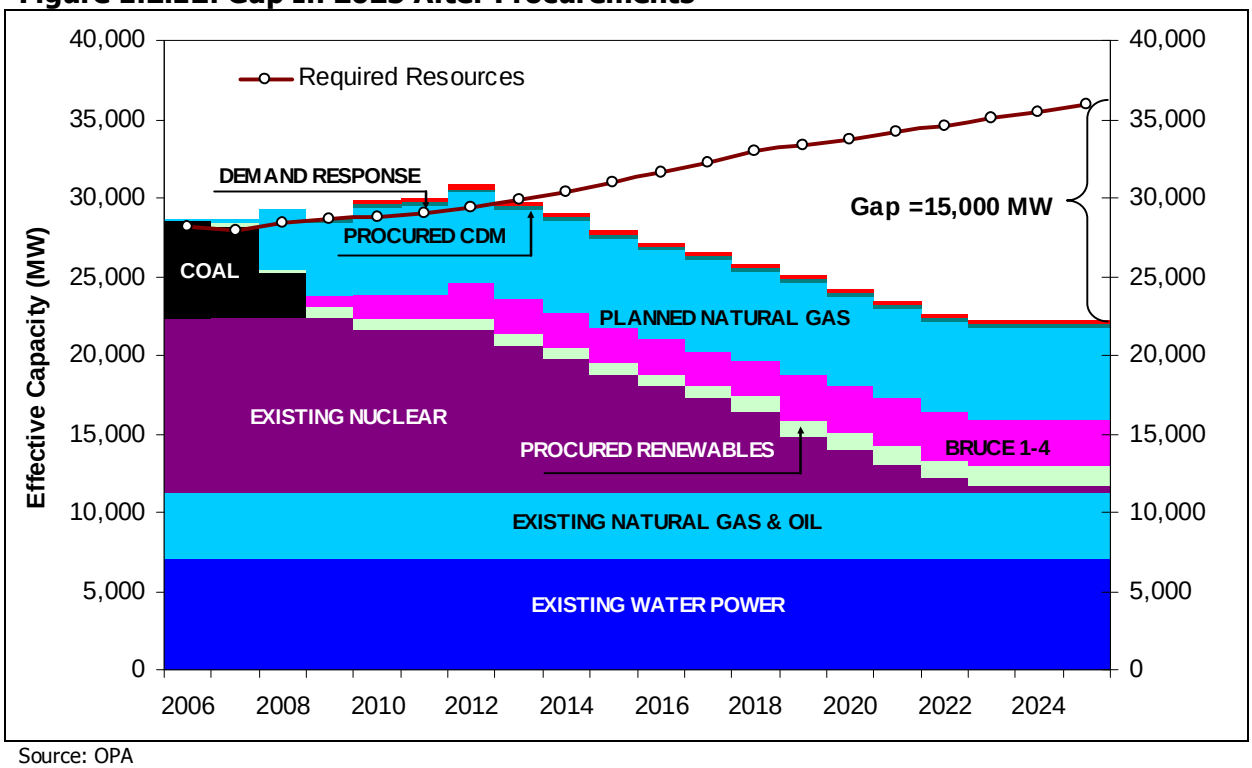
Additional Resources Already Planned by 2010	Nominal MW
Natural gas	5,990
Wind	1,390
Waterpower	150
Conservation and demand management	460
Landfill gas	30
Nuclear (Bruce A units 1 and 2)	1,500
Total procurements under way	9,520

Source: OPA

Table 1.2.14, in Appendix 2 (this section), provides an outline of the results of the Government's RFPs to date.

Given these assumptions about load growth and new capacity over the forecast period, the capacity needed still will amount to about 15,000 MW by 2025. This is shown in Figure 1.2.12. Of critical importance is that most of this 15,000 MW is for base-load generation capacity. This is significant because it dictates the types of resources which must be used to meet this need.

Figure 1.2.12: Gap In 2025 After Procurements



Source: OPA

Conservation and Demand Management (CDM):

The next step was to incorporate our planning assumptions around feasible CDM, which are depicted in Table 1.2.7.

Table 1.2.7: Conservation and Demand Management Assumptions

Conservation:	Planning Assumption (MW by 2025)	Higher Scenario (MW by 2025)
Conservation (incl. 200 MW in procurements)	1,050	3,550
Smart meters	500	500
DSM/Demand Reduction (including 260 MW in procurements)	260	260
Total CDM	1,810	4,310
Less CDM in procurement initiatives	460	460
CDM in addition to procurements	1,350	3,850

Source: OPA; Note: Assumes normal weather; conservation potential is higher on extreme weather days. These figures exclude cogeneration, which is included with natural gas-fired generation.

New Renewable Resources:

The figures for new renewables have some overlap with procurements. To illustrate the new renewables together and separate them from the procurements, Table 1.2.8 presents the total new renewables figures in both scenarios.

Table 1.2.8: New Renewable Sources, Installed Capacity

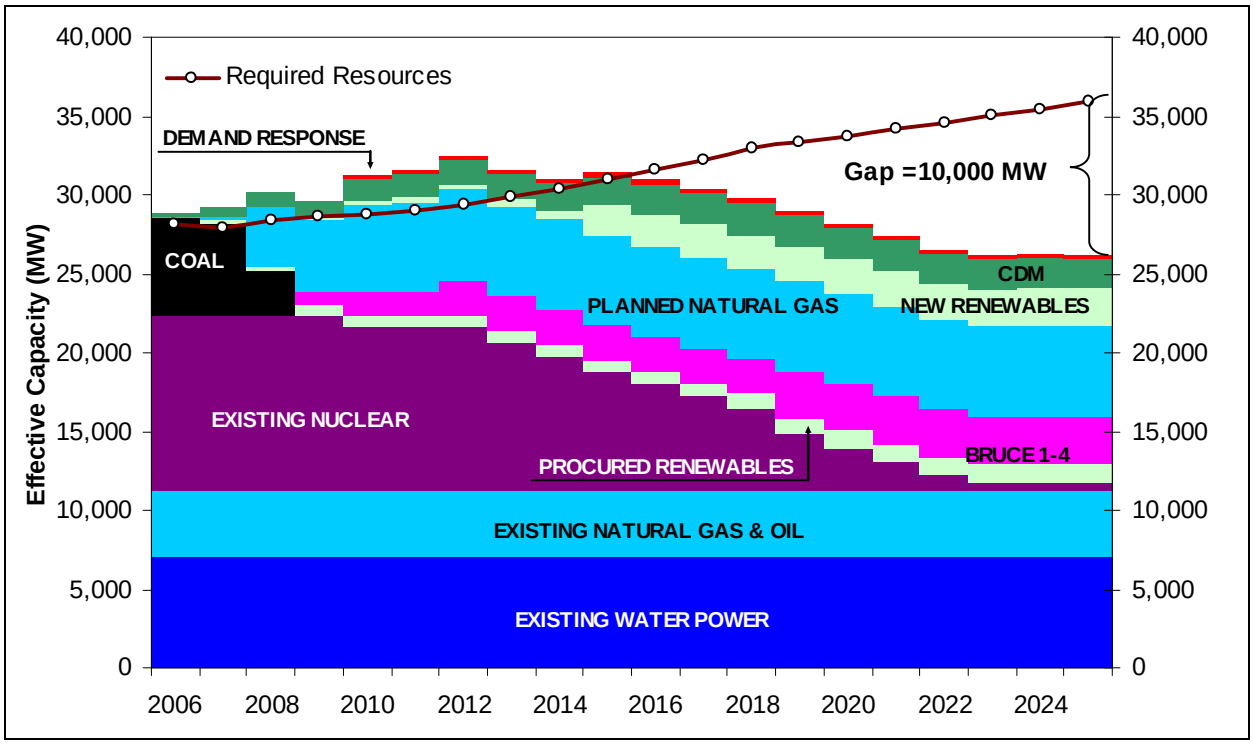
New Renewables	Planning Assumption (MW by 2025)	Lower Scenario (MW by 2025)
Biomass (including 28 MW in procurement)	500	250
Wind (including 1,391 MW in procurement)	5,000	2,500
Photovoltaic	40	20
Waterpower(including 151 MW in procurement)	1,500	600
Renewable Purchase	1,250	0
Total New Renewables	8,290	3,370
Less renewables in procurement initiatives	(1,570)	(1,570)
Total New Renewables in addition to procurement initiatives	6,720	1,800

Source: OPA

The contribution of current procurements, CDM and renewables is shown in Figure 1.2.13. The effective capacity associated with CDM and renewables closes the gap, leaving 10,000 MW of

effective capacity still to be planned by 2025. (Effective capacity is less than installed or nameplate capacity, as explained earlier).

Figure 1.2.13: Current Procurements, CDM and Renewables Cover Needs to 2015



Source: OPA

Strategies

Two strategies that were considered for meeting the needs beyond 2015 were heavier reliance on nuclear, versus heavier reliance on gas. These were the two options that the early screening indicated were promising.

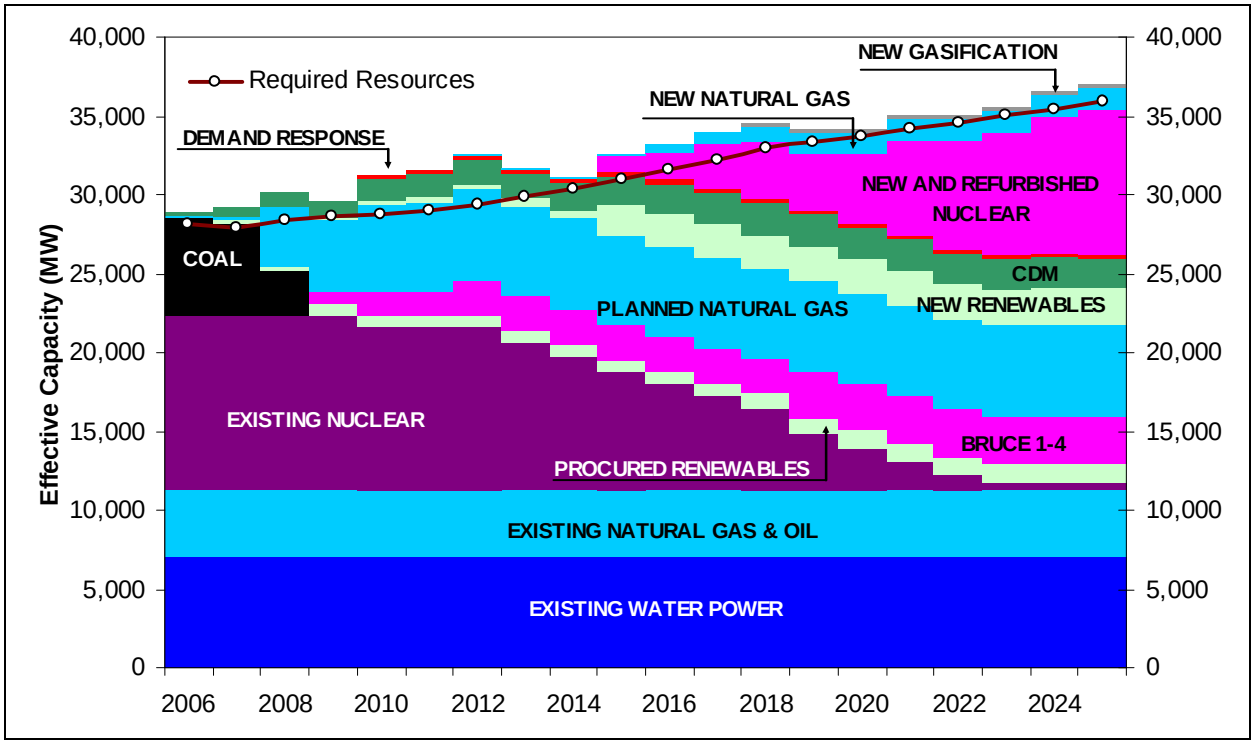
The assumptions about costs, risks and impacts of both nuclear and gas-fired generation were based on the discussion earlier in this report. Specifically:

- On nuclear generation, the analysis assumes the construction costs are $2,600 per KW of installed capacity. The levelized cost of $52/MWh, based on a discount rate of 5%, thus reflects the high end of the range shown for this discount rate in Figure 1.210.
- Refurbishments were assumed to be completed at a cost of $1.35 billion per unit. This is similar to the costs for the Bruce units 1 and 2 refurbishments.
- For gas-fired generation, the cost was based on a gas price of $8 per million BTU ($CDN), corresponding to the low end of the range provided in Figure 1.2.10, with the levelized cost

of $63/MWh corresponding to a discount rate of 5%

- For both sources, the risk distribution was based on historical volatility in gas prices and a range for construction cost variance of -15% to +35%

Figure 1.2.14: Meeting Additional Requirements to 2025 (With Nuclear and Gas)



Source: OPA

Gasification of coal on a large scale with sequestration could displace either nuclear or natural gas in future, should it become available at competitive prices, but could not be relied on as a definite supply source given its present state of development. Gasification of biomass or municipal solid waste is more likely to be developed, and is included in the scenario. Figure 1.2.14 illustrates how additional nuclear, natural gas and gasification can meet the remaining requirements.

A number of scenarios, which are described in the next section, were constructed to explore various possibilities and combinations of options. In our view, they all are possible. At the end of the analysis, we state, however, that it is not critical to decide now which scenario is more likely. There are common elements which constitute a common action plan and adaptation to the future as it unfolds will enable Ontario to respond to and take advantage of these scenarios.

Results

Planning Assumption Scenario: This scenario is based on procurements of 9,500 MW, coal replacement by 2009, new renewables and hydro imports of 6,700 MW and conservation and demand management of 1,800 MW, all according to planning assumptions. Two alternative portfolios were analyzed for this scenario:

- **Portfolio A:** Adds nuclear (9,400 MW) and natural gas fired-generation (1,000 MW), and fuel cells 500 MW starting in 2015
- **Portfolio B:** Adds natural gas-fired generation (9,300 MW), fuel cells (500MW) and coal gasification (720 MW)

Figure 1.2.15 shows the effective capacity for Portfolio A and Figure 1.2.16 shows the associated energy production. Figure 1.2.17 and 1.2.18 show effective capacity and energy production associated with Portfolio B.

The estimated costs of the portfolios were similar, but the risks were larger in Portfolio B and the environmental impact is larger. This is a direct result of the cost estimates and the environmental impacts scores described earlier. The details of the analysis are in Volume 2.

The conclusion is that Portfolio 1A offers lower risk and environmental impact than does Portfolio 1B. Variations on this scenario were then tested to determine the potential impact of other outcomes.

High Conservation Scenario:

This scenario showed the effects of higher success in harvesting conservation potential than the planning assumptions. Figures 1.2.19 and 1.2.20 illustrate what the effective capacity and corresponding energy production might look like if this materialized.

If it is assumed that the cost for all the conservation is lower than either nuclear or natural gas, then the result is that this scenario has lower cost, risk and environmental impact.

As sufficient confidence develops over the next several years that such a large potential for CDM is achievable, then the plans can adjust to take advantage of the increase in CDM. One possible adjustment shown in Figure 1.2.19 is to scale back on 1,200 MW of natural gas and 1,250 MW of hydro imports.

Figure 1.2.15: Scenario 1A – Nuclear for Base Load – Effective Capacity

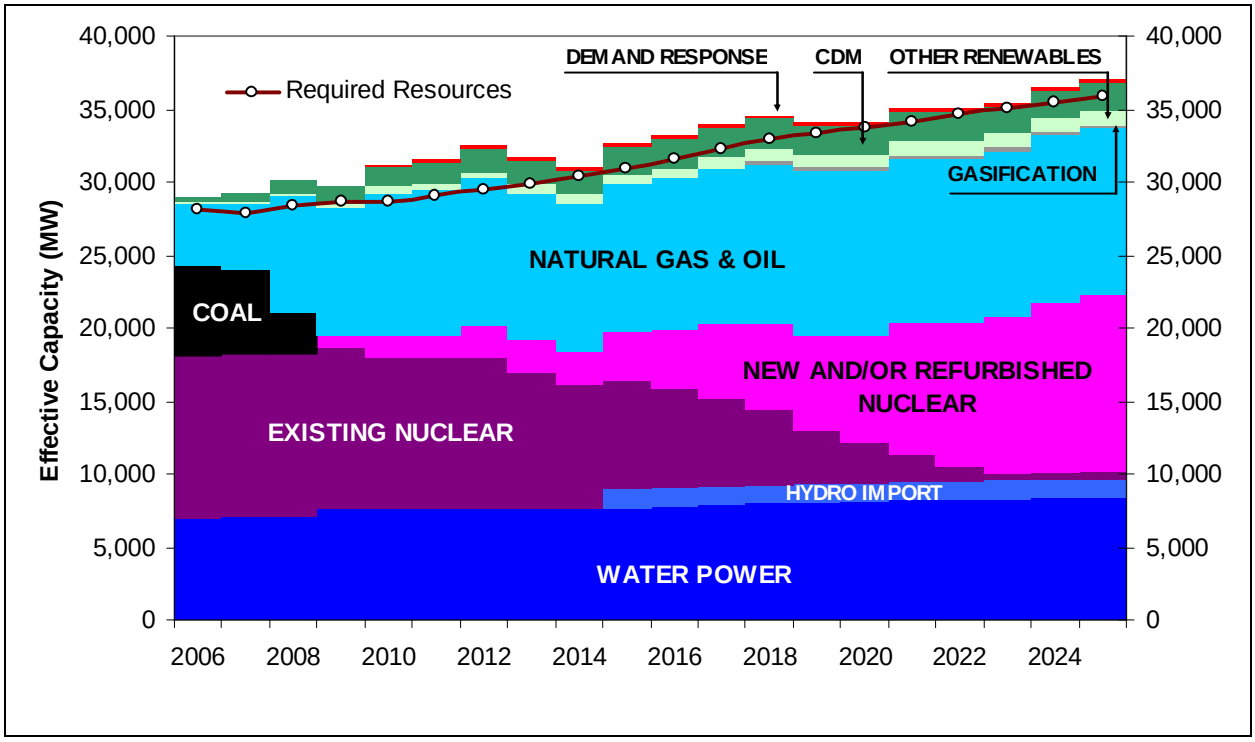
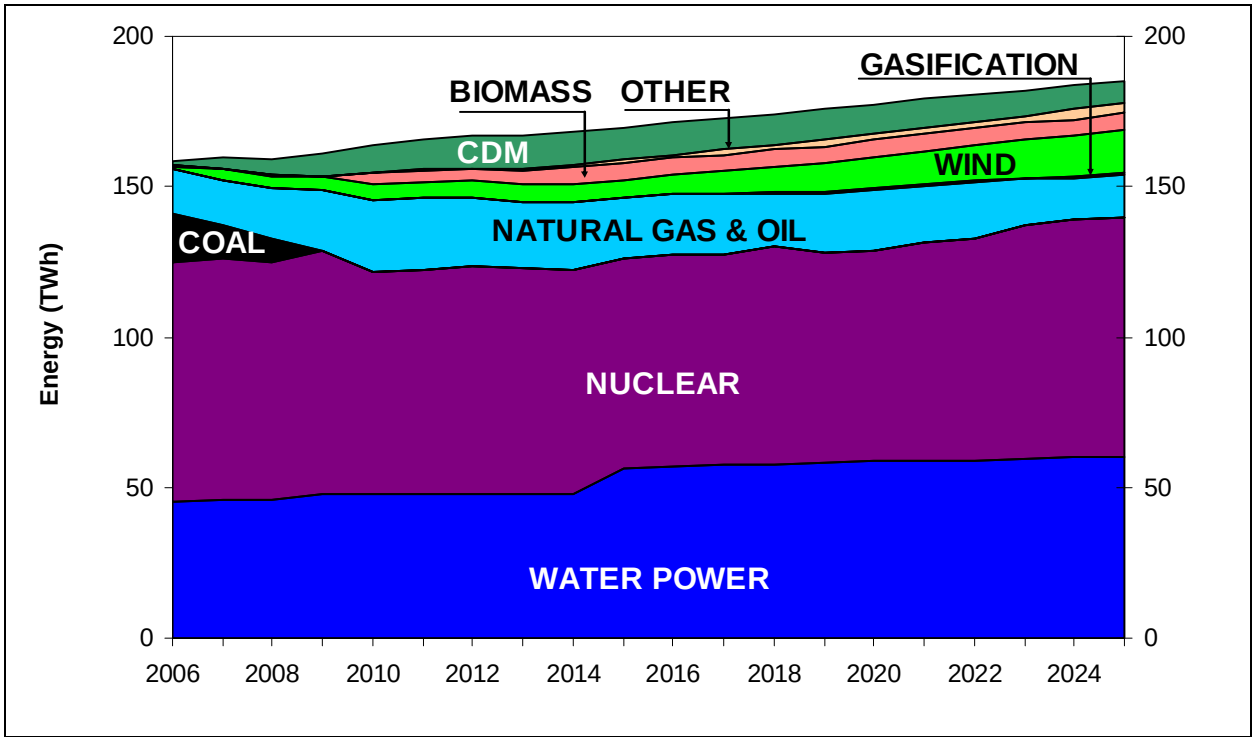


Figure 1.2.16: Scenario 1A – Nuclear for Base Load – Energy Production



Source: OPA

Figure 1.2.17: Scenario 1B – Natural Gas for Base Load – Effective Capacity

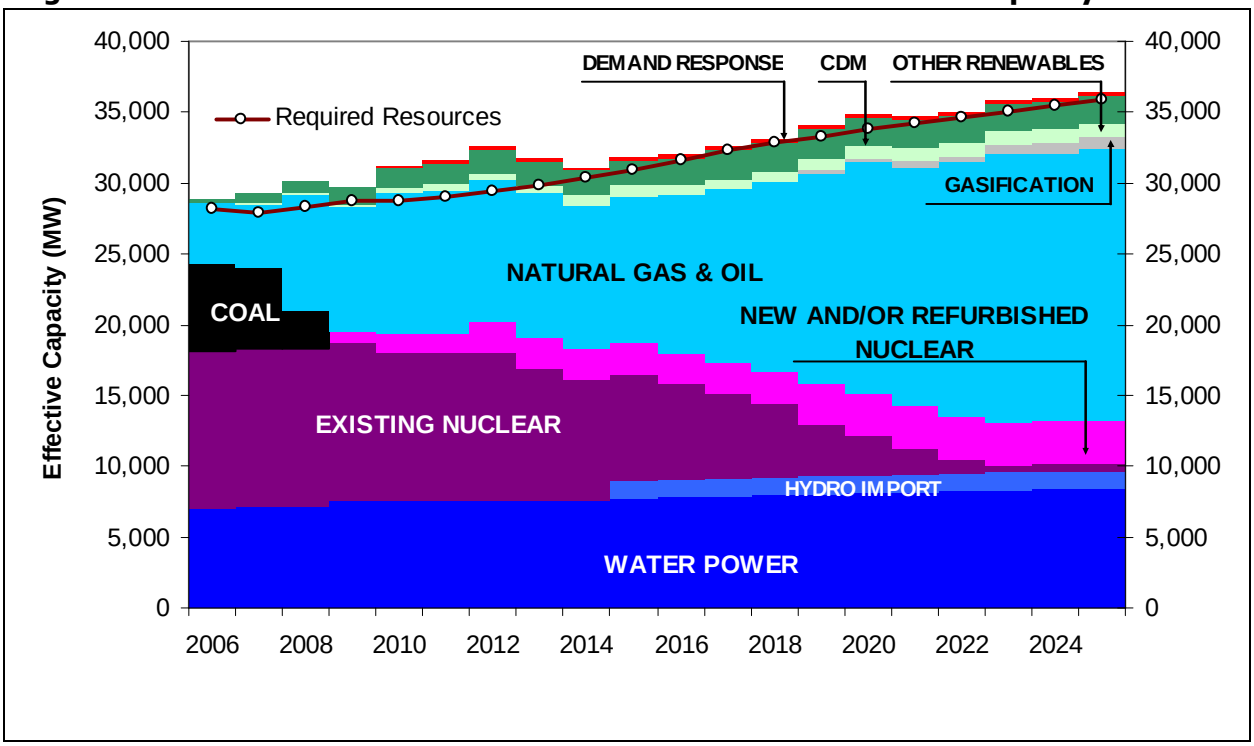
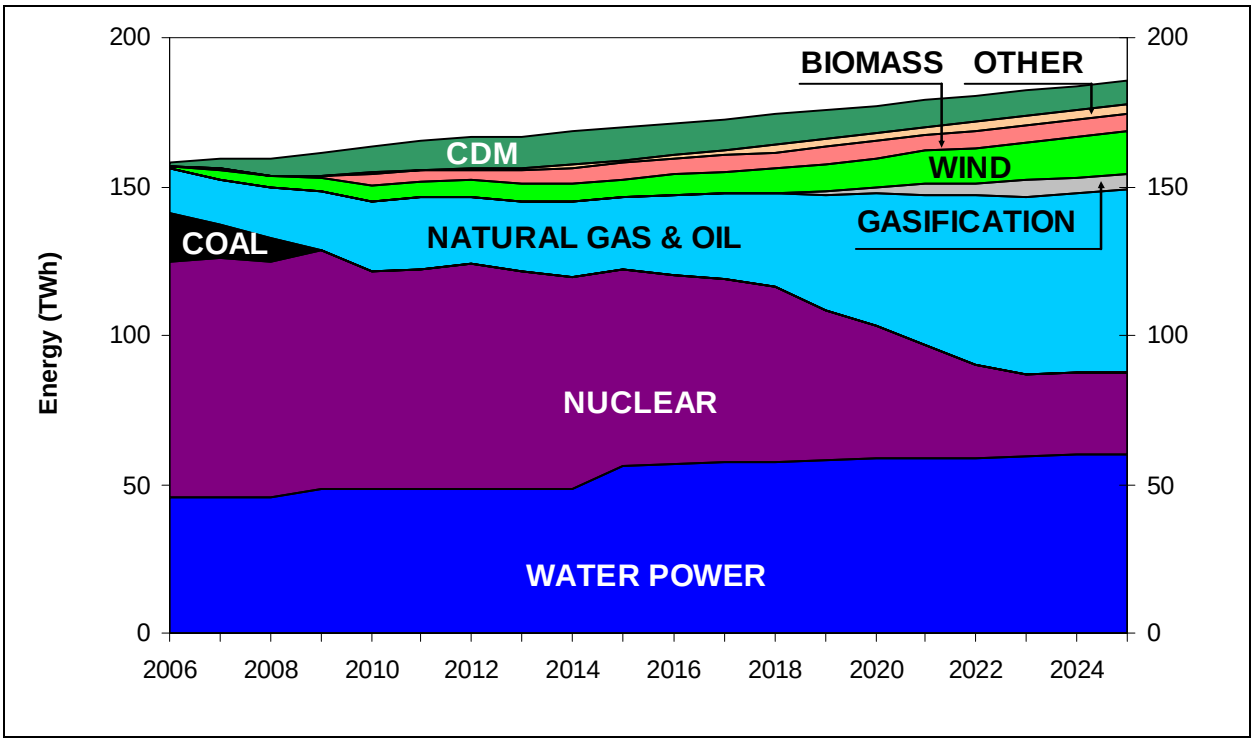


Figure 1.2.18: Scenario 1B – Natural Gas for Base Load – Energy Production



Source: OPA

Figure 1.2.19: Scenario 5B – Higher Success In Harvesting Conservation Potential – Effective Capacity

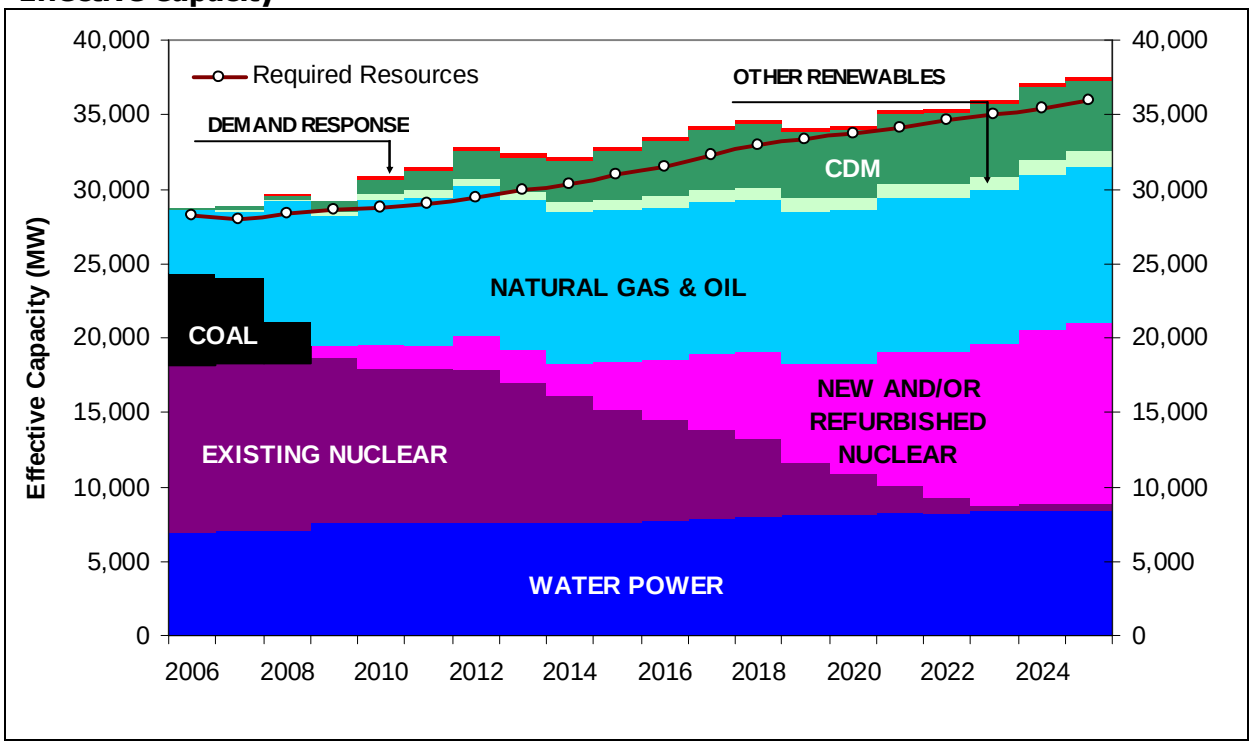
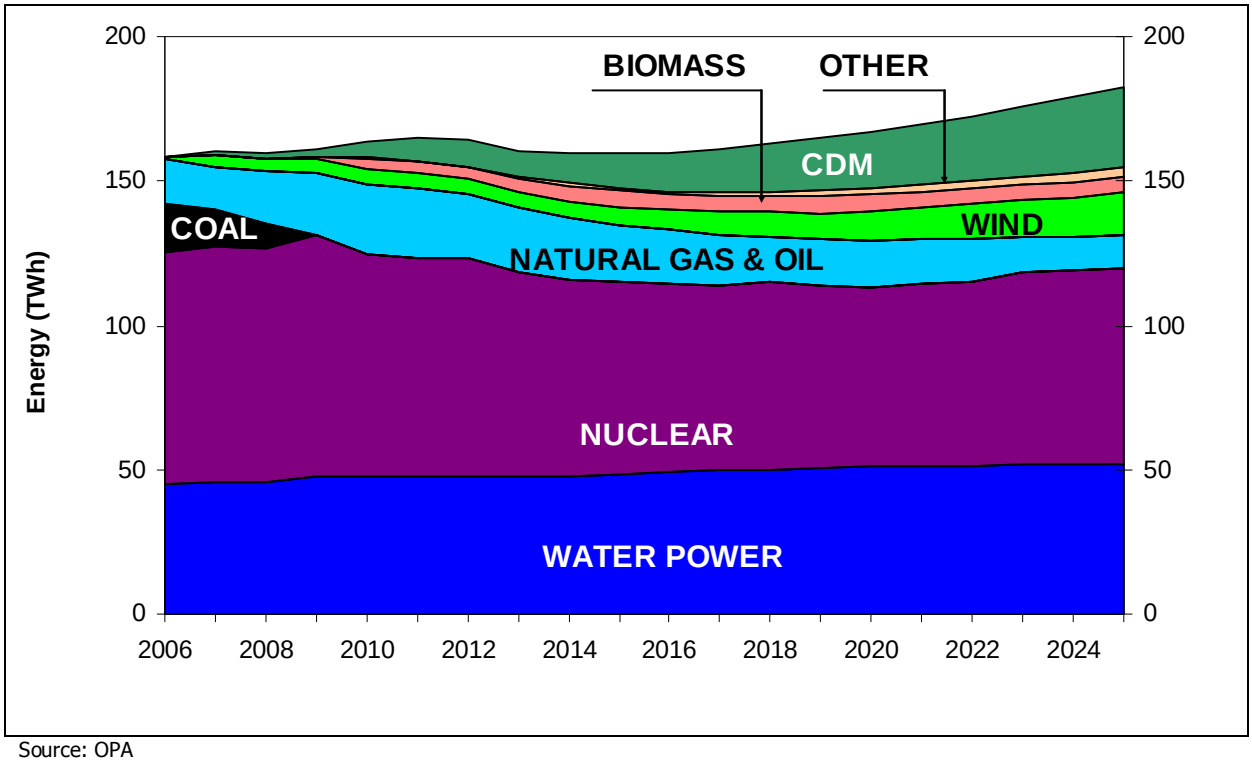


Figure 1.2.20: Scenario 5B – Higher Success In Harvesting Conservation Potential – Energy Production



Source: OPA

High Demand Scenario:

This scenario considered higher than expected growth in demand. This analysis quantifies the larger amount of resources required under such scenarios. The details are in Volume 2.

Delayed Coal Replacement Scenario:

This scenario explored the consequences of an unavoidable extension of the coal-fired generation replacement schedule. The results, in Volume 2, analyze how the portfolio can adjust in such an unavoidable delay.

Low Renewables Scenario:

This scenario looked at the possibility of lower-than-expected supply from renewables, no hydro imports, less cogeneration. The results, in Volume 2, quantify the larger requirements of either natural gas or nuclear to fill the shortfall and analyze the consequences of both strategies.

1.2.9 Recommended Supply Mix

This section provides specific response to the Minister's request for supply mix recommendations in the areas of conservation, renewables and additional supply. The recommendations are based on the basis of 0.9% per year load growth for energy production and 1.3% per year for installed capacity.

With Respect to Conservation:

The first requested recommendation is for conservation targets for the long term. OPA is not in a position to recommend long-term conservation targets at this time. The Chief Electricity Conservation Officer will address targets at a future date. In the meantime, the current target set by government for 2007 is sufficient to mobilize efforts and focus until further targets are set.

Recommendations on Conservation and Demand Management (CDM):

All economic conservation potential should be pursued as a matter of priority. For supply planning purposes, include 500 MW for smart metering, 260 MW for CDM and/or demand reductions, and 1,050-1,500 MW of efficiency improvement, with the range from energy efficiency showing the potential on an average day versus an extreme weather day. A total of 1,810 MW of CDM is therefore a prudent planning assumption for supply planning purposes by 2025. This is in addition to currently set targets and procurement initiatives under way.

With Respect to New Renewables:

The second requested recommendation is for additions of new renewable energy capacity. OPA recommends 3,000 MW by 2015, 5,000 MW by 2020, and 6,700 MW by 2025. These are in addition to currently set targets and procurements under way. In this respect, OPA makes the following recommendations.

Recommendation on Wind Power:

Ontario's future supply mix should include up to 5,000 MW of wind-powered generation by 2025, with 3,600 MW in addition to procurements already under way. This will be about 15% of Ontario's supply mix.

Recommendation on Waterpower:

Ontario's future supply mix should include up to 1,500 MW of additional waterpower resources by 2025, that is with 1,350 MW in addition to procurements under way. This includes the potential for pumped storage if it is economic to develop.

Recommendation on Hydro Imports:

For planning purposes, scenarios can consider up to 1,250 MW of hydro imports in the supply mix. This figure does not correspond to any of the projects discussed and is a rough estimate only, taking into account both the considerable potential and the considerable uncertainties involved.

Recommendation on Biomass:

Ontario's electricity supply mix should include up to 500 MW of biomass-powered generation, with 470 MW in addition to current procurements. Collection of methane from municipal landfills and wastewater plants and gasification of municipal solid waste should be considered as a component of this biomass planning assumption.

Recommendation on Solar Photovoltaic:

For planning purposes, up to 40 MW of solar-powered generation should be included in Ontario's electricity supply mix.

With Respect to Supply Sources for Remaining Demand:

The third requested recommendation is for the appropriate mix of electricity supply resources to satisfy the remaining expected demand in Ontario. In this respect, OPA makes the following recommendations.

Recommendation on Nuclear Power:

Ontario will require significant additions of nuclear power generation. Nuclear generation by 2025 should amount to between 12,900 MW and 15,900 MW. Of this capacity, there is already 3,500 MW that will be in place in 2025 made up of either what is already refurbished (Pickering A) or what is being refurbished (Bruce A). Ontario will therefore need between 9,400 to 12,400 MW of nuclear to be added by 2025. This should be achieved through at least the refurbishments of currently operating units, where it is economic, or replacement where it is not economic. Additional new capacity, beyond replacement, will also be required in certain scenarios.

Recommendation on Natural Gas:

Ontario's supply mix should not include significantly more natural gas-fired generation than has already been contemplated by recent procurement directives. While natural gas prices are expected to decline from their current all time high levels, we still recommend that any further additions should be part of a "smart gas" strategy that stresses the advantages of natural gas and limits the unnecessary exposure to price and supply risk. In addition to the current procurements, the portfolio should include up to 1,500 MW of natural gas. This may be 500 MW of fuel cells or other distributed generation and 1,000 MW of generation for relief of transmission bottlenecks.

Recommendation on Gasification:

The coal-handling facilities at existing coal-fired plants should remain in place after the replacement of coal-fired generation, in case gasification becomes economically and environmentally feasible in future. The recommendations include 250 MW of gasification towards the end of the planning period as we expect technologies acceptable to Ontario may become feasible.

Recommendation on Coal-fired Generation:

Schedule risks in the replacement of coal-fired generation should continue to be monitored closely. If required, alternatives should be developed to ensure the success of the coal replacement policy. The replacement should be completed in the context of the government's stated position that reliability is the "first principle" of the replacement plan.

Table 1.2.9 provides a summary of the supply resource recommendations. Tables 1.2.15 and 1.2.16, in Appendix 2 (this section), provide a listing of all the procurements and the recommendations beyond procurements.

Summary of Recommendations

Table 1.2.9: In Summary, Installed Capacity (MW)

	Existing Facilities Remaining in Service by 2025	Procurement Initiatives	Recommend-ation Beyond Procurement	Total Additions to 2025	Recommend-ation (Total, Existing and Additions)
CDM	0	460	1,350 – 3,850	1,810 – 4,300	1,810 – 4,300
Renewables	7,810	1,570	6,720	Up to 8,300	Up to 16,100
Nuclear	515	3,000	9,400 - 12,400	12,400 - 15,400	12,900 – 15,900
Natural Gas	5,000	6,000	750 – 1,500	Up to - 7,500	Up to 12,500
Gasification	0	0	250	250	250

Source: OPA

A Robust Portfolio

The analysis of the five scenarios, and sensitivities around them, confirmed the merits of a diversified portfolio of nuclear generation for base load, natural gas-fired generation for peaking, and renewables for energy production. This analysis suggested, at a minimum, keeping nuclear capacity at its current level through refurbishments and "new-build" nuclear, and adopting a "smart gas" strategy that takes advantage of the attractive features of natural gas without unnecessarily increasing exposure to price and supply risks. Adding renewables to the extent that is economically achievable reduces the environmental impact and risk.

The portfolio that can respond to any of these scenarios and take advantage of future developments is outlined in Table 1.2.10. A representative estimate of the cost of capital expenditures over the 20 years of the plan is $70 billion, made up of the cost elements in the same table.

Table 1.2.10: A Robust Portfolio for Meeting a Range of Scenarios

Resource	Installed Capacity (MW)	Capital Costs (as spent $Billions)
Conservation	1,800 to 4,300	5 – 11
Renewables	13,900 to 16,100	14 – 22
Natural gas-fired generation	10,200 to 12,500	7 – 10
Nuclear power	12,900 to 15,900	30 – 40

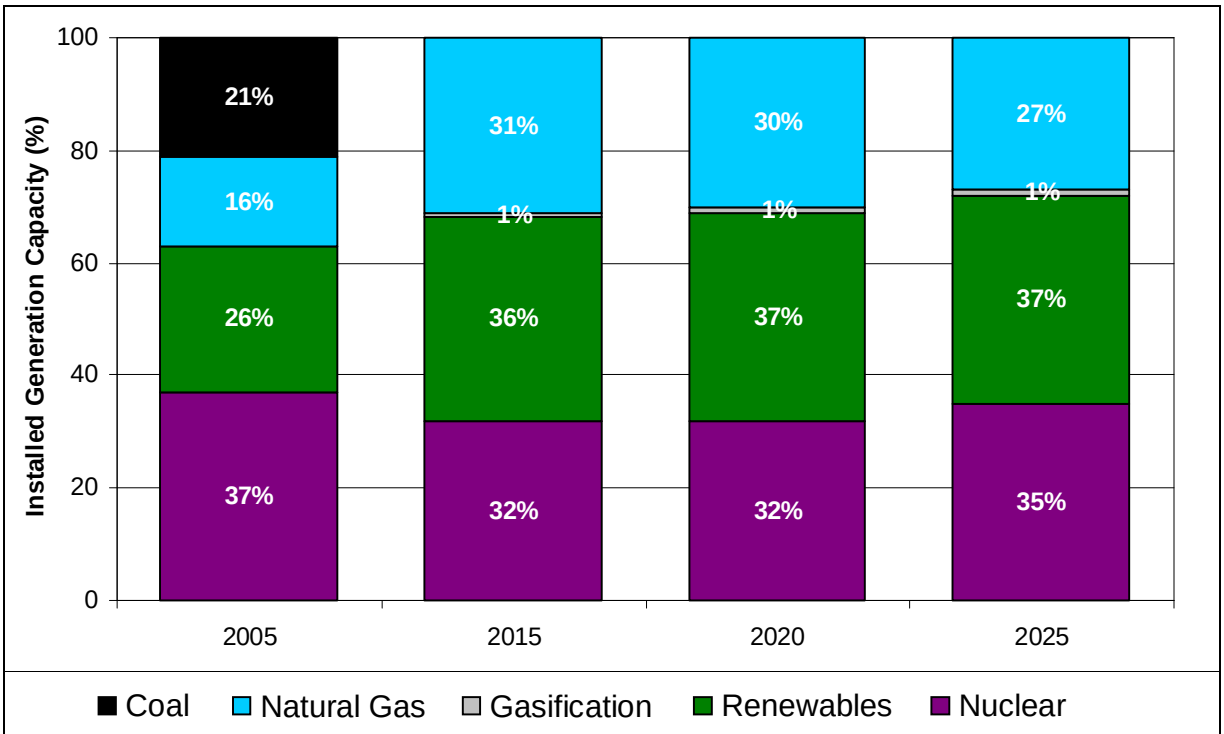
Source: OPA

The $70 billion capital expenditure averages $3.5 billion per year over the twenty-year period. To provide some context, the total of all electricity bills in Ontario is $12 billion per year. In

addition to the capital costs in Table 1.2.10, there are significant operating, fuel and maintenance costs. A detailed analysis of costs is in Volume 2.

Recommended Supply Mix Outcomes in 2015, 2020, and 2025

Figure 1.2.21: Supply Mix Recommendations – Installed Generation Capacity

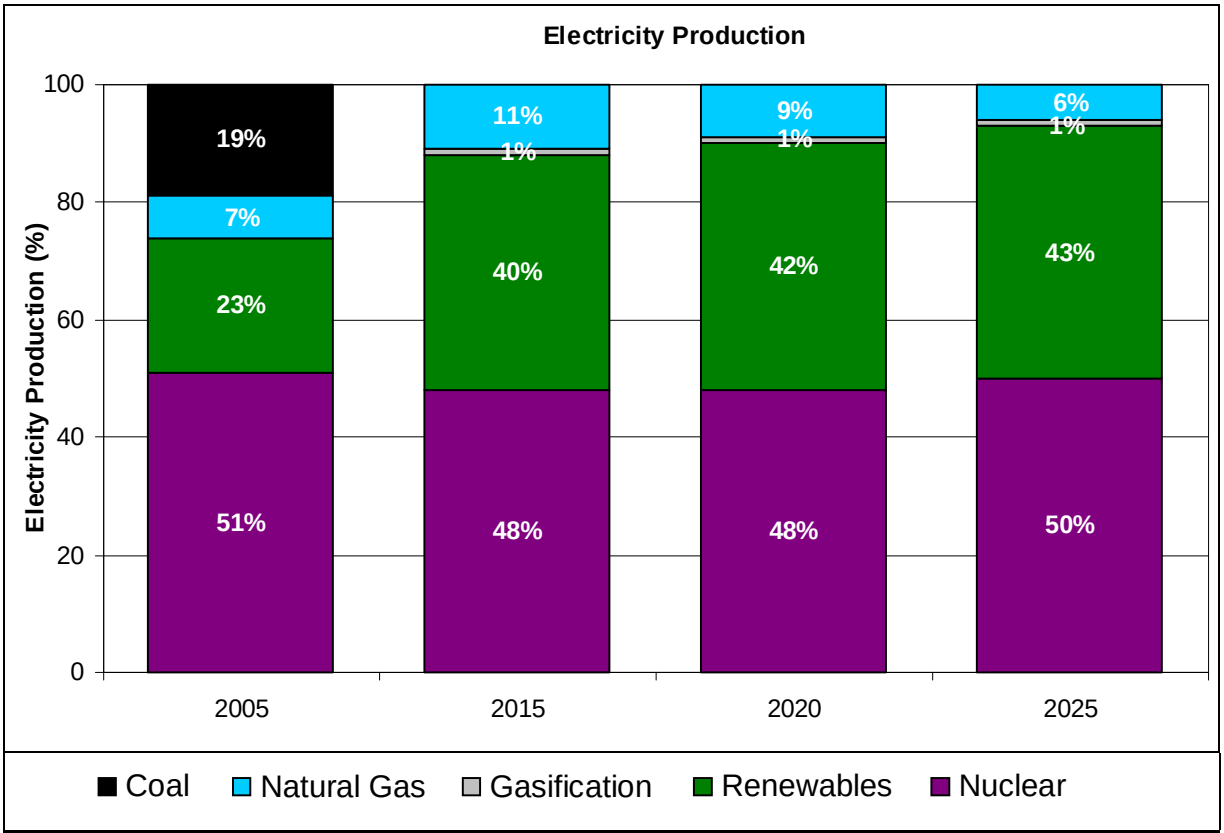


(%)	2005	2015	2020	2025
Nuclear	37	32	32	35
Renewables	26	36	37	37
Gasification	0	1	1	1
Gas	16	31	30	27
Coal	21	0	0	0

(MW)	2005	2015	2020	2025
Nuclear	11,397	11,000	12,000	15,000
Renewables	7,855	12,000	14,000	15,500
Gasification	0	125	250	250
Gas	4,976	10,500	11,000	11,000
Coal	6,434	0	0	0
Total	30,662	33,625	37,250	41,750

Source: OPA

Figure 1.2.22: Supply Mix Recommendations – Electricity Production



(%)	2005 (Estimate)	2015	2020	2025
Nuclear	51	48	48	50
Renewables	23	40	42	43
Gasification	0	1	1	1
Gas	7	11	9	6
Coal	19	0	0	0

(TWh)	2005 (Estimate)	2015	2020	2025
Nuclear	79	76	81	89
Renewables	36	64	71	77
Gasification	0	2	2	2
Gas	11	17	15	11
Coal	29	0	0	0
Total	155	159	169	179

Source: OPA

The average contribution of each option was calculated by averaging the three scenarios that were examined – the planning assumption scenario, low renewables and delayed coal replacement. See Tables 1.2.11 through 1.2.14 in Appendix 2 (this section) for the details. Additional explanation of this calculation is in Part 2.8 of Volume 2 of this report.

Results Delivered from Supply Mix Recommendations

Based on the above recommendations, the resulting contribution of renewables, natural gas, nuclear and gasification to the supply of electricity in Ontario to 2025 is illustrated in Figures 1.2.21 and 1.2.22. By adopting the above recommendations, the Minister of Energy would be in a position to set Ontario on a course to:

- Maximize conservation and demand management and their potential in the future
- Pursue as aggressive a course for renewables as is possible within current constraints, while looking at ways to reduce these constraints
- Implement base load options that need a long lead time, such as nuclear, hydro imports and gasification.
- Replace the current coal-fired generation in ways that manage the risks effectively.

Supply Mix Action Plan to Ensure Future Reliability and Flexibility

The following form the top ten elements of a prudent "action plan" for meeting Ontario's electricity capacity needs while managing environmental, economic and social risks.

1. Be ready to adapt for different possible futures, such as up to 1.8% annual growth in demand for energy production and capacity, while recognizing that the actual outcome is likely to be lower, close to 0.9% annual growth in demand.

    - Recognize that growth is uneven across Ontario, with growth in some parts of the GTA more than double the provincial average.

2. Move immediately to capture conservation opportunities and build the capability to better assess conservation and demand management potential.

3. Acquire up to 5,000 MW of wind generation, especially for winter needs, and up to 1,500 MW of waterpower over the planning period. This would include facilitating small waterpower developments that are available, along with extensions and upgrades to existing sites and exploring pumped storage feasibility.

    - Take into account system integration and transmission connection considerations to incorporate wind and waterpower and investigate how they can be collected together in an optimal way.

4. Seek to achieve full biomass and waste potential to generate electricity (estimated to be up

to 500 MW), and full solar photovoltaics potential (up to 40 MW).

- Accelerate development of gas from landfill, wastewater and forest and agricultural waste in the short term.
- Assess barriers to the wider use of farm and forest waste and municipal solid waste to generate electricity.

5. Continue to monitor closely risks to the coal replacement schedule as it progresses and develop alternatives if circumstances change.

- Keep the existing coal-fired generation infrastructure – at a minimum, the coal-handling facilities – until coal replacement is complete and the potential future use of coal gasification is more certain.

6. Adopt a "smart gas" strategy by using gas only in high-efficiency applications or applications where avoided costs are particularly high; these will include combined heat and power (CHP), cogeneration, peaking, relieving transmission constraints, and fuel cells, or other distributed generation.

- Do not use natural gas for base-load generation, since this use results in higher exposure to natural gas price risks.
- Recognize that natural gas will be more available for power generation in the summer, and will complement the operating characteristics of wind power.

7. Pursue hydro imports by continuing talks with neighbours for potential firm purchases, explore imports that can be scheduled and can meet intermediate load requirements. Assess transmission needs and the required associated permitting/approvals process.

8. Investigate the potential to refurbish existing nuclear units. Begin this immediately because the scope is complex and requires extensive planning and coordinating.

- Coordinate other resource availability to ensure adequate supply during the periods of nuclear refurbishment.

9. Initiate approvals and permitting for new nuclear of up to 3,000 MW in addition to replacing the current fleet for a total capacity of up to 15,900 MW by 2025. This additional capacity will be needed if other options do not materialize or if load growth is higher than 0.9% a year.

- Define a process that enables new nuclear development as early as possible, with scope to include proponent, site, technology and environmental assessment.

10. There is one further element to consider in making this proposed plan a reality: the need to develop transmission integration policies and plans, particularly as they relate to facilitating coal replacement, integration of renewables, and access to neighbouring markets. This is not strictly an element of supply mix, and so will be dealt with in more detail in the Integrated Power System Plan. Given the urgency of the needs, however, we recommend immediate initiatives to streamline approvals to ensure that necessary electricity system infrastructure can be developed with greater certainty than is possible at present.

Conclusion

In summary, we believe the recommendations and action plan, together, outline the critical path that will ensure a reliable electricity future that can also meet the Ontario Government's policy objectives for conservation, renewables and coal replacement.

1.2.10 Appendix 1: Remainder of the Supply Mix Volumes

Volume 1: Remainder of the Advice and Recommendation Report

- Compendium of Recommendations from Supply Mix and Annual Report of the OPA's Chief Energy Conservation Officer
- Compendium of Advice for OPA Supply Mix and Other Consultations
- Report Contributors
- Table of Contents and Figures for Remaining Volumes
- Glossary of Terms

Volume 2: Analysis Report

The purpose of this volume is to provide additional context and more details about how OPA conducted its analysis. The volume:

- Describes in more detail what the OPA was asked to do by the Minister
- Describes the societal context within which power system planning is taking place
- Summarizes what we heard from stakeholders
- Describes how other jurisdictions are approaching integrated planning
- Explains what criteria we used for developing and evaluating options and scenarios
- Provides more details on the analytical methodology we adopted
- Consolidates the relevant information on supply options that were considered
- Goes through the analysis of portfolios and scenarios and the results
- Provides conclusions with observations and insights gleaned from the analysis

Volume 3: Supporting Documents

The purpose of this volume is to share with stakeholders the background research that we conducted in areas that are critical to the task, as well as some basic information for those who are less familiar with this sector. These include:

- The evolution of power system planning in Ontario
- The applicability and relevance of sustainability principles to power system planning
- The state of Ontario's power system today and the basics on how it works
- The concepts of conservation and demand side management
- The concepts for dealing with uncertainties and risk analysis
- An analysis of the potential for additional hydroelectric power in Ontario
- A review of the provisions for managing nuclear spent fuel and decommissioning costs
- A status of gasification technology

- A review of the natural gas supply and price context

Volume 4: Consulting Reports

- Modelling and portfolio screening – Navigant Consulting
- Conservation and demand management – ICF Consulting
- Supply option technologies and resources – Canadian Energy Research Institute (CERI)
- Environmental impact assessment – SENES Consultants
- Stakeholdering – Decision Partners
- Wind resources – Helimax Energy

Volume 5: Supply Mix Submissions and Presentations (web only)

- Submissions
- Presentations

1.2.11 Appendix 2: Detailed Supply Mix Numbers

Table 1.2.11: Mixes Resulting From Three Scenarios in 2025

	Installed Capacity (MW), Range of Three Scenarios	% of Installed Capacity	Average of Installed Capacity (%)	Energy (TWh), Range of Three Scenarios	% of Energy	Average Energy (%)	Effective Capacity for Meeting Summer Peak (MW), Range of Three Scenarios	Effective Capacity for Meeting Summer Peak (%)	Average % of Effective Capacity for Meeting Summer Peak
Renewables	13,900 - 16,100	34% - 39%	37%	69 - 83	39% - 47%	43%	8,600 - 10,700	25% - 31%	28%
Nuclear	12,900 - 15,900	31% - 38%	35%	80 - 102	45% - 57%	51%	12,600 - 15,600	36% - 45%	41%
Gas	10,200 - 12,500	24% - 30%	27%	6 - 14	4% - 8%	6%	9,300 - 11,400	27% - 33%	30%
Gasification	250	1%	1%	0.5	1%	1%	240	1%	1%
Coal	0	0%	0%	0	0%	0%	0	0%	0%

Source: OPA

Table 1.2.12: Mixes Resulting From Three Scenarios in 2020

	Installed Capacity (MW), Range of Three Scenarios	% of Installed Capacity	Average of Installed Capacity (%)	Energy (TWh), Range of Three Scenarios	% of Energy	Average Energy (%)	Effective Capacity for Meeting Summer Peak (MW), Range of Three Scenarios	Effective Capacity for Meeting Summer Peak (%)	Average % of Effective Capacity for Meeting Summer Peak
Renewables	12,600 - 14,600	34% - 40%	37%	63 - 77	38% - 46%	42%	8,400 - 10,500	26% - 33%	30%
Nuclear	10,300 - 13,300	28% - 36%	32%	70 - 92	42% - 55%	48%	10,100 - 13,00	32% - 41%	37%
Gas	10,200 - 12,300	27% - 33%	30%	12 - 20	7% - 12%	10%	9,300 - 11,300	29% - 35%	32%
Gasification	250	1%	1%	0.7 - 0.8	1%	1%	240	1%	1%
Coal	0	0%	0%	0	0%	0%	0	0%	0%

Source: OPA

Table 1.2.13: Mixes Resulting From Three Scenarios in 2015

	Installed Capacity (MW), Range of Three Scenarios	% of Installed Capacity	Average of Installed Capacity (%)	Energy (TWh), Range of Three Scenarios	% of Energy	Average Energy (%)	Effective Capacity for Meeting Summer Peak (MW), Range of Three Scenarios	Effective Capacity for Meeting Summer Peak (%)	Average % of Effective Capacity for Meeting Summer Peak
Renewables	11,200 - 12,800	33% - 38%	36%	59 - 69	37% - 43%	40%	8,200 - 10,000	28% - 33%	31%
Nuclear	11,000	32% - 33%	32%	70 - 83	44% - 52%	48%	10,800	35% - 37%	36%
`Gas	10,100 - 11,100	29% - 33%	31%	16 - 20	10% - 13%	12%	9,200 - 10,100	30% - 34%	32%
Gasification	0 - 250	0% - 1%	1%	0 - 0.8	1%	1%	0 - 240	0% - 1%	1%
Coal	0	0%	0%	0%	0%	0%	0	0%	0%

Source: OPA

Table 1.2.14: Mixes Resulting From Three Scenarios in 2010

	Installed Capacity (MW), Range of Three Scenarios	% of Installed Capacity	Average of Installed Capacity (%)	Energy (TWh), Range of Three Scenarios	% of Energy	Average Energy (%)	Effective Capacity for Meeting Summer Peak (MW), Range of Three Scenarios	Effective Capacity for Meeting Summer Peak (%)	Average % of Effective Capacity for Meeting Summer Peak
Renewables	10,700	31% - 33%	32%	56 - 57	37%	37%	8,000	26% - 28%	27%
Nuclear	12,100	35% - 37%	36%	74 - 79	48% - 51%	49%	11,900	38% - 41%	39%
Gas	8,200 - 10,800	23% - 32%	27%	18 - 24	12% - 15%	13%	7,300 - 9,800	24% - 33%	28%
Gasification	0	0%	0%	0	0%	0%	0	0%	0%
Coal	0 - 3,900	0% - 11%	5%	0 - 2	0% - 1%	1%	0 - 3,700	0% - 12%	6%

Source: OPA

Table 1.2.15: RFP Procurements

Procurement	Nominal MW
Clean Energy Supply (CES) RFP: (Greenfield Energy Centre, St. Clair Power, Greenfield South, GTAA, Loblaw Properties)	1,992
Renewable Energy Supply (RES) I	395
RES II	975
RES III	200
West GTA	1,000
Downtown Toronto	600
Cogeneration	1,000
Conservation and Demand Management (CDM) and Demand Reduction	250
Thunder Bay Replacement	310
York Region	200
Goreway Station	894
Bruce Units 1 – 2 (Bruce Units 3 - 4 will add another 1,500MW beyond 2010)	1,500
Low Income & Social Housing CDM	100
Lighting/Appliance CDM	100
Total (rounded up)	9,520

Source: OPA, Ministry of Energy, IESO

Table 1.2.16: Procurements and Recommendations Beyond Procurements as Installed MW

Resource	Procurement Under Way	Recommendation Beyond Procurement	Total Additions to 2025
CDM	460	1,350	1,810
Wind Power	1,391	3,609	5,000
Waterpower	151	1,349	1,500
Biomass	28	472	500
Photovoltaic	0	40	40
Hydro Imports	0	1,250	1,250
Nuclear Power	3,000	9,400 – 12,400	12,400 – 15,400
Natural Gas	5,986	750 – 1,300	6,736 – 7,286
Fuel Cells	0	500	500
Gasification	0	250	250
Total	10,556		

Source: OPA; * The total is not the sum of all the components above it because not all the options will be required at the same time.

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1.3 Compendium of Recommendations

1.3.1 Introduction

The purpose of this section is twofold. The first is to bring together the OPA's supply mix recommendations and action plan to ensure future reliability and flexibility for easy reference. Where part 1.2 outlines the supply mix recommendations in the context of discussion of CDM or the renewable or conventional resource, part 1.3 provides them as a compendium of what is found in part 1.2.

The second purpose is to supplement the supply mix recommendations with the recent recommendations in the Annual Report of the Chief Conservation Officer. Together, the two groups of recommendations outline the current positions of OPA collectively on meeting Ontario's future electricity needs.

1.3.2 Supply Mix Recommendations

1.3.2.1 With Respect to Conservation:

The Minister's first requested recommendation is for conservation targets for the long term. OPA is not in a position to recommend long-term conservation targets at this time. The Chief Electricity Conservation Officer will address targets at a future date. In the meantime, the current target set by government for 2007 is sufficient to mobilize efforts and focus until further targets are set.

Recommendations on Conservation and Demand Management (CDM):

All economic conservation potential should be pursued as a matter of priority. For supply planning purposes, include 500 MW for smart metering, 260 MW for CDM and/or demand reductions, and 1,050-1,500 MW of efficiency improvement, with the range from energy efficiency showing the potential on an average day versus an extreme weather day. A total of 1,810 MW of CDM is therefore a prudent planning assumption for supply planning purposes by 2025. This is in addition to currently set targets and procurement initiatives under way.

1.3.2.2 With Respect to New Renewables:

The Minister's second requested recommendation is for additions of new renewable energy capacity. OPA recommends 3,000 MW by 2015, 5,000 MW by 2020, and 6,700 MW by 2025. These are in addition to currently set targets and procurements under way. In this respect, OPA makes the following recommendations.

Recommendation on Wind Power:

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Recommendation on Waterpower:

Ontario's future supply mix should include up to 1,500 MW of additional waterpower resources by 2025, that is with 1,350 MW in addition to procurements under way. This includes the potential for pumped storage if it is economic to develop.

Recommendation on Hydro Imports:

For planning purposes, scenarios can consider up to 1,250 MW of hydro imports in the supply mix. This figure does not correspond to any of the projects discussed and is a rough estimate only, taking into account both the considerable potential and the considerable uncertainties involved.

Recommendation on Biomass:

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Recommendation on Solar Photovoltaic:

For planning purposes, up to 40 MW of solar-powered generation should be included in Ontario's electricity supply mix.

1.3.3.3 With Respect to Supply Sources for Remaining Demand:

The Minister's third requested recommendation is for the appropriate mix of electricity supply resources to satisfy the remaining expected demand in Ontario. In this respect, OPA makes the following recommendations.

Recommendation on Nuclear Power:

Ontario will require significant additions of nuclear power generation. Nuclear generation by 2025 should amount to between 12,900 MW and 15,900 MW. Of this capacity, there is already 3,500 MW that will be in place in 2025 made up of either what is already refurbished (Pickering A) or what is being refurbished (Bruce A). Ontario will therefore need between 9,400 to 12,400 MW of nuclear to be added by 2025. This should be achieved through at least the refurbishments of currently operating units, where it is economic, or replacement where it is not economic. Additional new capacity, beyond replacement, will also be required in certain scenarios.

Recommendation on Natural Gas:

Ontario's supply mix should not include significantly more natural gas-fired generation than has already been contemplated by recent procurement directives. While natural gas prices are expected to decline from their current all time high levels, we still recommend that any further additions should be part of a "smart gas" strategy that stresses the advantages of natural gas and limits the unnecessary exposure to price and supply risk. In addition to the current procurements, the portfolio should include up to 1,500 MW of natural gas. This may be 500 MW of fuel cells or other distributed generation and 1,000 MW of generation for relief of transmission bottlenecks.

Recommendation on Gasification:

The coal-handling facilities at existing coal-fired plants should remain in place after the replacement of coal-fired generation, in case gasification becomes economically and environmentally feasible in future. The recommendations include 250 MW of gasification towards the end of the planning period as we expect technologies acceptable to Ontario may become feasible.

Recommendation on Coal-fired Generation:

Schedule risks in the replacement of coal-fired generation should continue to be monitored closely. If required, alternatives should be developed to ensure the success of the coal replacement policy. The replacement should be completed in the context of the government's stated position that reliability is the "first principle" of the replacement plan.

Table 1.2.9 provides a summary of the supply resource recommendations. Tables 1.2.15 and 1.2.16, in Appendix 2 (this section), provide a listing of all the procurements and the recommendations beyond procurements.

Summary of Recommendations

Table 1.2.9: In Summary, Installed Capacity (MW)

	Existing Facilities Remaining in Service by 2025	Procurement Initiatives	Recommend-ation Beyond Procurement	Total Additions to 2025	Recommend-ation (Total, Existing and Additions)
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Nuclear	515	3,000	9,400 - 12,400	12,400 - 15,400	12,900 – 15,900
Natural Gas	5,000	6,000	750 – 1,500	Up to - 7,500	Up to 12,500
Gasification	0	0	250	250	250

Source: OPA

1.3.4 Supply Mix Action Plan to Ensure Future Reliability and Flexibility

The following form the top ten elements of a prudent "action plan" for meeting Ontario's electricity capacity needs while managing environmental, economic and social risks.

1. Be ready to adapt for different possible futures, such as up to 1.8% annual growth in demand for energy production and capacity, while recognizing that the actual outcome is likely to be lower, close to 0.9% annual growth in demand.

    - Recognize that growth is uneven across Ontario, with growth in some parts of the GTA more than double the provincial average.

2. Move immediately to capture conservation opportunities and build the capability to better assess conservation and demand management potential.

3. Acquire up to 5,000 MW of wind generation, especially for winter needs, and up to 1,500 MW of waterpower over the planning period. This would include facilitating small waterpower developments that are available, along with extensions and upgrades to existing sites and exploring pumped storage feasibility.

    - Take into account system integration and transmission connection considerations to incorporate wind and waterpower and investigate how they can be collected together in an optimal way.

4. Seek to achieve full biomass and waste potential to generate electricity (estimated to be up to 500 MW), and full solar photovoltaics potential (up to 40 MW).

    - Accelerate development of gas from landfill, wastewater and forest and agricultural waste in the short term.
    - Assess barriers to the wider use of farm and forest waste and municipal solid waste to generate electricity.

5. Continue to monitor closely risks to the coal replacement schedule as it progresses and develop alternatives if circumstances change.

- Keep the existing coal-fired generation infrastructure – at a minimum, the coal-handling facilities – until coal replacement is complete and the potential future use of coal gasification is more certain.

6. Adopt a "smart gas" strategy by using gas only in high-efficiency applications or applications where avoided costs are particularly high; these will include combined heat and power (CHP), cogeneration, peaking, relieving transmission constraints, and fuel cells, or other distributed generation.

    - Do not use natural gas for base-load generation, since this use results in higher exposure to natural gas price risks.
    - Recognize that natural gas will be more available for power generation in the summer, and will complement the operating characteristics of wind power.

7. Pursue hydro imports by continuing talks with neighbours for potential firm purchases, explore imports that can be scheduled and can meet intermediate load requirements. Assess transmission needs and the required associated permitting/approvals process.

8. Investigate the potential to refurbish existing nuclear units. Begin this immediately because the scope is complex and requires extensive planning and coordinating.

    - Coordinate other resource availability to ensure adequate supply during the periods of nuclear refurbishment.

9. Initiate approvals and permitting for new nuclear of up to 3,000 MW in addition to replacing the current fleet for a total capacity of up to 15,900 MW by 2025. This additional capacity will be needed if other options do not materialize or if load growth is higher than 0.9% a year.

    - Define a process that enables new nuclear development as early as possible, with scope to include proponent, site, technology and environmental assessment.

10. There is one further element to consider in making this proposed plan a reality: the need to develop transmission integration policies and plans, particularly as they relate to facilitating coal replacement, integration of renewables, and access to neighbouring markets. This is not strictly an element of supply mix, and so will be dealt with in more detail in the Integrated Power System Plan. Given the urgency of the needs, however, we recommend immediate initiatives to streamline approvals to ensure that necessary electricity system infrastructure can be developed with greater certainty than is possible at present.

1.3.5 Chief Energy Conservation Officer Recommendations

On the goals of a 5% reduction in peak electricity demand and a 10% reduction in consumption by provincial operations, the CECO recommends that:

1. The targets and evaluation efforts should be weather corrected and account for structural changes in the economy;
2. Actual electricity consumption by provincial operations should be measured and reported;
3. Conservation plans should be prepared and posted by all government ministries, agencies, municipalities, universities and hospitals. The plans should be measurable and verifiable.

On Provincial Energy Policy and Conservation, the CECO recommends that:

4. The government continue public consultation on its conservation strategy and goals;
5. The government complete the various elements of its strategy and publish the policy, strategy tactics and a plan for ongoing success measurement in one document;
6. The government, the Bureau, the OEB and the IESO build on informal meetings currently being held to establish a formal working group to review the criteria for CDM program delivery and funding. The working group would recommend the appropriate criteria and tests, and determine whether regulation or legislative amendment is needed. Although each of these organizations may be mandated to act autonomously, a common understanding would help to advance the effective delivery of conservation programs;
7. The Conservation Action Team play a policy integration and monitoring role within government.

On the Ontario Energy Efficiency Act, the CECO recommends that:

8. The Ministry of Energy dedicate staff and resources for further study of appropriate energy efficiency standards through either the CSA process or the government's own assessment;
9. Further analysis be done on ways to phase out the installation of T12 fluorescent lamps and to promote the use of T8 or T5 lamps;

10. CSA window performance standard A440.2-04 be reviewed and consideration be given to incorporating these changes into the Ontario Energy Efficiency Act.

On Changes to the Ontario Building Code, the CECO recommends that:

11. Consider incorporating higher minimum energy efficiency standards into the Ontario Building Code, such as increasing the minimum energy efficiency standards for electrically heated houses, and requiring renovations to meet the same minimum energy efficiency requirements as new buildings.
12. Expedite the public consultation and approvals process to make changes to the Building Code in recognition of the urgent need to address energy conservation issues.

On Natural Gas Back-Up Generators, the CECO recommends that:

13. Expedite the review and public process necessary for the adoption regulations to permit use of natural gas for backup generators.

On Financial Incentives for Hospitals and Schools, the CECO recommends that:

14. Broaden the group eligible for low-cost financing to include hospitals and schools.

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1.4 Compendium of Key Findings

This part presents the key findings for the Supply Mix Analysis Report (Volume 2) and the Supply Mix Background Report (Volume 3). The key findings are reprinted directly from each volume, as indicated by the section headings below, and are run together here for the convience of the reader.

1.4.1 OPA Task (From Part 2.1)

- Integrated Power System Plan (IPSP) is a 20-year plan that must be updated and approved on a three-year cycle, with approval received before the Ontario Energy Board (OEB)
- IPSP's rolling renewal dictates that the plan's purpose is to establish what needs to be done in the first three years from the picture found over the plan's 20 years
- OPA's task is to assess the available conservation and demand management (CDM), renewable and conventional resources in a manner that preserve options in the future
- IPSP's objective is to set in motion the range of initiatives required to meet Ontario's future electricity needs, recognizing that the plan is an evolving instrument
- Supply mix advice instructions are to consider CDM as a resource to be deployed before considering supply resources
- Renewables are to be treated not unlike CDM, to be established prior to consideration of conventional resources
- Conventional resources are to be determined after an examination of CDM and renewables: Conventional Resources = Total Demand + Required Reserves – CDM Resources – Renewable Resources

1.4.2 Ontario Context (From Part 2.2)

- A new equilibrium exists in Ontario where market forces and centralized planning co-exist; the reintroduction of planning in 2004 follows the introduction of a market framework in 2002, and its subsequent partial curtailment in late 2002
- Electricity's economic impact has been significant historically as "power at cost" facilitated private sector growth; the pragmatic consensus for public ownership became unhinged in the early 1990s
- Ontario has harvested its excess generating capacity since the recession of the early 1990s and developed a reliance on imports
- Population alone dictates a very large electric system in Ontario; the Golden Horseshoe is forecast to have 71% of total population in 2025
- Demand growth increased 7% per year, on average, through to the 1960s

- Capital spending on nuclear in 1970s was $1.5 billion per year with an economic multiplier of 1.5 – a *de facto* industrial strategy – but stagflation meant the policy was not sustainable; Ontario Hydro's 1989 "demand-supply" plan included a large nuclear station, but the recession intervened
- Waterpower and uranium from Canadian Shield were critical for power generation; inter-connection of transmission within Ontario in the 1950s made it possible to develop the waterpower of northern Ontario for use in the south; after all large waterpower sites had been exhausted by the 1950s, coal fired generation was adopted as an interm measure, nuclear power became the dominant source of generation
- Early environmentalism sought to manage natural resources for public good; post-war human welfare ecology addressed societal impact; deep ecology focuses on value of non-human life independent of human needs and purposes; the challenge of power system planning is to balance the societal consensus for renewables with these other environmental concerns

1.4.3 What Did OPA Hear from the Public and Stakeholders? (From Part 2.3)

- Advice and comments were received from the public and stakeholders over several phases of supply mix consultations , including 185 written submissions, 30 industry, environmental and academic expert presentations, in-depth interviews with stakeholders, and public opinion polling were undertaken
- Public submissions provided OPA with advice regarding appropriate criteria to consider in analytical approaches to planning, approaches to conservation and demand management (CDM), generation resources and technologies for the supply mix and appropriate methods to assess impacts on the natural environment
- Industry, environmental and academic experts provided OPA advice on contributions from various supply resources, policy barriers to new generation development, transmission and connection barriers, electricity price signals, areas for energy efficiency savings, risks associated with certain supply resources, and the state of several new technologies which may impact the supply mix over the supply mix planning horizon
- In-depth interviews and public opinion polling reinforced several findings from other consultation activities, including the importance of availability and reliability as drivers of the supply mix, environmental responsibility and sustainability as key decision criteria, as well as the challenges of implementing current plans to replace coal-fired generation
- Public and stakeholder consultation assisted OPA substantially in addressing planning and supply mix challenges, documenting public policy challenges and developing approaches for balancing public and private interests in the supply mix, in addition to providing a solid foundation for moving forward in 2006 to develop the integrated power system plan (IPSP)

1.4.4 What are Other Jurisdictions Doing? (From Part 2.4)

- IRP approaches give equal consideration to demand and supply options and therefore can give careful analysis to CDM options, as well as renewable technologies and policy issues
- OPA's current approach on "supply mix" advice falls generally within the definition of IRP, but could be characterized as "modified IRP" because, like California, policy favours demand and renewable supply options
- CDM programs are an integral part of electric system planning and policy in many jurisdictions worldwide; CDM programs have the ability to reduce or reshape demand loads, provide direct and indirect economic benefits, and mitigate environmental impacts
- No jurisdiction has "unfettered" competitive markets and all recognize regulatory planning intervention as a backstop for supply adequacy; IRP has re-emerged in many jurisdictions as a required planning methodology. In this sense, Ontario is not atypical
- Advances in computing power and increased familiarity with risk and probability concepts have moved risk analysis beyond simple decision tree analysis to more sophisticated scenario and risk/return analysis, although using it for analyzing plans with a full range of demand and conventional and alternative supply options is still relatively rare
- A common approach is to use portfolio techniques only to analyze the most preferred mix of conventional supply options, then to use this initial plan to determine the economic criteria (such as avoided costs) that are then applied in the determination of the amounts of renewables and CDM that are economic
- International Energy Agency (IEA) has estimated that one-third of new power generation investment in OECD countries will be in renewable energy over the next 30 years
- Technology standardization and familiarity by financiers are increasing sources of renewable energy investments; a range of financial interests (commercial lenders, venture capitalists, banks) is stimulating private investment, especially in Europe
- Renewable energy manufacturing, operations and maintenance are having a substantial impact worldwide on job creation
- Renewable energy sources supply 17% of the world's primary energy, from sources including traditional biomass, large hydropower and new renewables (small hydro, modern biomass, wind, solar, geothermal and bio-fuels)

1.4.5 What are the Challenges? (From Part 2.5)

- Ontario's supply mix is being shaped by replacement of coal-fired generation, retirement of nuclear units, and growing electricity demand
- Current demand and consumption trends will lead to a large resource gap that will need to be met by conservation and new or refurbished generation capacity, most of which will need to be base-load power

- CDM can reduce requirements to increase supply, but the exact potential for energy efficiency improvements is uncertain in terms of technical (feasible), economic and achievable (cost effective) potential
- OPA received two estimates of CDM potential beyond what is assumed in the load forecast across four differing energy efficiency scenarios that reflect increasingly aggressive levels of conservation
- OPA's estimates on CDM contributions to reducing peak demand on an average summer day cover a wide range and can adapt to the effectiveness of CDM programs
- Key uncertainties for supply mix include unpredictability of future natural gas prices and availability, impacts of transitioning to supply resources currently existing only in small amounts or not at all, and uncertainty regarding future policy choices and social values and behaviours that influence conservation
- Some uncertainty regarding the supply mix is relieved through current procurement processes for new generation and demand-side resources
- OPA has included potential environmental impacts of the supply mix and environmental attributes of several generation portfolios
- OPA has compared portfolios in terms of both absolute impacts and environmental loading scores; the latter normalize different environmental impacts using a common scale for comparison; each portfolio is compared on the basis of its environmental loading score

1.4.6 What Methodology and Assumptions Have OPA Adopted (From Part 2.6)

- OPA has adopted the Independent Electricity System Operator's (IESO) most recent 10-Year Outlook, dated July 2005, as its base load forecast and extrapolated it for the supply mix planning period
- IESO's "top-down" forecast was adopted, in part, because the data on end use of electricity necessary to produce a "bottom up" forecast have been unavailable for the past decade in Ontario; like all energy forecasts, the current forecast has an inherent uncertainty
- Peak demand in Ontario is forecast to increase by 1.3% per year, while energy requirements are forecast to increase at 0.9% per year
- Power systems require a balance of resource characteristics to serve different requirements for power, energy, operating reserve, and other services throughout the day and night
- Ontario's load curve has a significant ramp up of 5,000 MW in the morning and a matching ramp down in the evening – generating technologies differ in their ability to change output to follow this ramping
- OPA has adopted a reserve margin of 18% for the longer term
- A level of 65% of total capacity being base load is judged appropriate for Ontario over the next 20 years; peaking/intermediate resources would make up the remainder
- OPA has screened each supply resource option on the basis of its life-cycle environmental impacts

- OPA has analyzed both the "absolute" environmental impacts (such as tonnes of a particular pollutant) and "scored" impacts (that quantify all impacts on the same basis, permitting calculation of the total environmental impact of an option or portfolio)
- Economic assessments were performed both for individual options and for portfolios of options, on a lifetime basis, including allowance for costs beyond 2025
- Risk and uncertainty were key aspects of the economic analysis that included analysis of sensitivity to uncertain parameters and scenario analysis of the robustness of portfolios to different scenarios, for example, higher load growth

1.4.7 What Are the Available Resources and Their Impacts? (From Part 2.7)

- Levelized unit energy cost (LUECs) are an important overall measure of the cost of an option; a summary measure of the average cost of electricity per kilowatt-hour expressed in current dollars or dollars of a specified year
- LUECs are commonly used in studies for comparing the cost of power from competing technologies
- LUEC is defined as the price of electricity output required by a plant to recover exactly the net present value of all capital, operation and maintenance, fuel, and decommissioning costs expected to be incurred over its economic life
- Environmental characteristics are generally grouped by contaminant emissions, greenhouse gases, radioactivity, land use, water withdrawal and consumption, waste and resource availability.
- The life-cycle environmental impact of renewable generation technologies is less than that of both nuclear and fossil fuel generation. Using the weighting of environmental categories recommended by SENES, nuclear generation performs better than fossil fuel generation, including combined cycle natural gas and gasification with sequestration of carbon dioxide.
- Technical performance of various supply technologies are assessed with respect to costs, and environmental loading (air, land, water and waste impacts)
- cost and environmental characteristics for a range of supply options and technologies are examined

1.4.8 Description of Scenarios and Portfolios (From Part 2.8)

- Five scenarios were constructed to illustrate possible futures
- Two portfolios of resource options were developed as alternative responses to each of the five scenarios
- Each portfolio was selected to illustrate the drivers and risks that are shaping Ontario's supply mix and integrated planning challenge
- Each portfolio was analyzed to understand cost, financial risk, and environmental impact

- The common elements assigned to most portfolios are:
    - 1,800 MW of conservation through energy efficiency and demand management
    - 5,000 MW of wind power
    - 1,500 MW of additional waterpower
    - 1,250 MW of out-of-province purchases
    - 500 MW of biomass generation
    - 40 MW of solar photovoltaic generation
    - 500 MW of fuel cell generation
    - 250 MW of gasification

1.4.9 Analysis Results (Part 2.9)

- Early recognition of changes in assumptions, such as greater success in capturing conservation or delayed coal replacement, has advantages,
- A robust portfolio should enable adaptation to take advantage of evolving trends.
- The portfolios tend to show similar environmental impacts and costs, as they share many common elements.
- Environmental impacts are greatest where there is greater use of fossil fuel-based resources.
- Greatest cost-related differences relate to risk around costs.
- The main driver of higher risk is natural gas price variability; portfolios with greater reliance on natural gas tend to exhibit higher risk.
- In general, portfolios that use less fossil fuel resources present lower costs and environmental impacts and are less exposed to risk; these portfolios are more robust, performing better under different possible futures except under a future with low gas prices.

1.4.10 Overview of the Development of Power System Planning in Ontario (From Part 3.1)

- Until the 1970s, power system planning was essentially an exercise to meet ever-increasing demand, with growth averaging 7% annually
- By the 1950s, Ontario's large waterpower sites were largely exhausted and alternate sources of generation, namely coal and nuclear power, had to be considered
- By the 1960s, the environmental and social issues of power system planning suggested that expansion of the power system would no longer be accepted simply as a public good
- By 1980, demand growth in Ontario had already slowed to 3.2% and demand management came to be considered as a component of electric power planning
- Ontario Hydro's 1989 Demand/Supply Plan was the only previous integrated power system planning exercise, but was withdrawn when economic circumstances changed

- Ontario's electricity industry was restructured under the Energy Competition Act, 1998, followed in 2002 by the opening of the market and its reliance on market forces rather than planning for new generation resources
- The partial curtailment of the market in late 2002 and the fact that only a limited amount of new generation capacity materialized, led to a renewed consideration of the need for supply planning
- The 2004 Electricity Conservation and Supply Task Force (ECSTF) concluded that the market approach alone would not produce the needed generation, and that Ontario needed a long-term planning function, a conservation champion, and a contracting function to serve as a credit-worthy counterparty to investors in new generation capacity
- The Ontario Power Authority was created as a feature of the Electricity Restructuring Act, 2004, in keeping with the ECSTF recommendations.

1.4.11 Sustainability Principles and Integrated Planning (From Part 3.2)

- OPA is committed to the pursuit of environmental sustainability in a fashion that preserves economically sustainability
- OPA supports the 1987 Bruntland Commission interpretation of sustainable development as that "which meets the needs of the present without compromising the ability of future generations to meet their own needs"
- As an initial step, OPA has analyzed each supply resource on the basis of its life-cycle environmental impacts, and put all resources on a common quantitative basis by developing "scored" formats, using weightings developed in the European Union.
- In developing its supply mix advice, OPA monetized carbon dioxide emissions and included these costs in its economic analysis of supply options
- OPA included considerations of environmental impacts beyond the end of the study period; i.e. beyond (2025) in an attempt to reflect considerations of inter-generational equity as well as intra-generational equity
- The precautionary principle, which is often invoked to "operationalize" the sustainability concept, counsels that proactive action to prevent harm is required where the potential for major harm exists, but can be difficult to apply when faced with trade-offs
- Until 2001, private sector energy facilities were not subject to environmental assessment (EA) requirements; the Electricity Projects Regulation (O.Reg.116/01) established private and public sector projects as equally subject to the EA process

1.4.12 Character of Ontario's Current Electricity System (From Part 3.3)

- Energy demand is greater in the winter than in the summer, since winter heating and lighting more than compensate for summer air conditioning
- Peak demand is now greater in summer than in winter because of air conditioning load
- Peak demands in the summer are stressing the supply/demand balance to the point of load interruption, despite the addition of some generation to the supply
- Lack of energy storage in the power system means supply must be flexible and responsive enough to follow the deviations between forecast and actual load each day
- Ontario's interconnection capability amounts to between 3,150 MW and 4,050 MW
- Ontario and Manitoba have negotiated short-term supply from Manitoba to Ontario, and a longer-term possibility of about 1,300 MW is under consideration
- Purchases from Manitoba or Quebec/Labrador, and potentially from as far away as the Alberta tar-sands would involve major transmission enhancements and would be an important step in creating an inter-provincial grid

1.4.13 Conservation and Demand Management Issues (From Part 3.4)

- CDM activities fall into conservation (absolute reduction in use), energy efficiency (achieving the same function using less energy), and load management (shifting use to different times or interruption of use at peak times)
- Energy efficiency gains can be achieved through new codes and standards for manufacturing appliances and for new buildings, and by providing financial incentives for end users to switch to more efficient products and services
- Load control initiatives include critical peak pricing policies, load interruption agreements and consumer responses to requests for demand reduction
- CDM involves intervention by an authority, such as a government or regulator, to introduce new codes or standards, or to provide direct financial incentives and/or information
- Savings from CDM are supplemented by those from market mechanisms, such as an energy services company that provides more efficient equipment to an electricity user in exchange for a share of the resulting savings, or an electricity user that bids demand reduction into the Ontario spot market (i.e. agrees to curtail consumption in return for financial compensation)
- The Ontario context for CDM includes continuing absolute growth in the demand for electricity, but ever lower electricity intensity. That is, more goods and services are produced for a given level of demand for electricity (decreasing electricity intensity)
- High growth in commercial and institutional electricity demand is due mainly to lighting, which remains a promising area for CDM programs. This rate of demand growth has outpaced advances in efficient lighting and other electricity end uses

- Residential and commercial air conditioning loads have doubled since 1990; this is one of the most promising areas for large DSM gains
- Ontario Hydro's large-scale DSM/CDM programs of the late 1980s were cancelled in the early 1990s; however, DSM/CDM initiatives have continued at the municipal and federal levels

1.4.14 Portfolio Diversification and Risk Analysis (From Part 3.5)

- Risk analysis of specific groupings of resource options (portfolios) was a central element of the supply mix advice exercise
- Risk in the electricity sector stems from uncertainties regarding several key factors – fuel price variability and long-term fuel supply, costs and performance of various technologies, generator availability, load growth over time and population and economic factors that influence load, changes in electricity use patterns, and weather impacts
- OPA approached the supply mix exercise from a risk perspective, where risk associated with investments in new supply can be reduced by diversifying generation portfolios
- Risk associated with the various generation portfolios was modeled using the Monte Carlo simulation statistical method which uses sequences of random numbers to simulate what could happen to variables affecting portfolio performance and measuring the resulting distribution of the output parameter (expected cost)
- OPA variables used to run Monte Carlo simulations were fuel prices, load, technology cost, hydro and wind availability, and forced outage rates
- Once the simulations were run for the candidate portfolios, OPA used their respective expected cost and risk (distribution of cost) to compare the portfolios
- Sensitivity analyses were completed to assess portfolio performance given the event of a sudden change in one of the relevant variables

1.4.15 Hydroelectric Generation in Ontario (From Part 3.6)

- Ontario's switch from winter to summer peaking has created limitations for hydroelectric facilities having no or limited water storage because summer peaks are sustained over longer periods of time than are winter peaks; moreover, rainfall is at its lowest, and restrictions on water use are at their greatest during the summer
- Waterpower that a "dispatchable" from a control centre is most beneficial to the power system because it can be activated when it is most needed
- Hydroelectric resources are best suited for providing frequency regulation, an essential component in keeping a steady 60 Hz frequency across the province and inadvertent power exchanges with our neighbours to a minimum
- Ontario has 190 potential waterpower sites capable of 7,521 MW but only 1,447 MW could be developed within existing public policy guidelines – another 1,501 MW are inside

provincial parks and a further 4,637 MW are subject to agreement with First Nations and the federal government
- Transmission unavailability and the cost of new transmission are the largest impediments to developing potential hydroelectric sites in the northern portions of the province
- Hydroelectric facilities are renewable, sources of electricity that do not consume water
- Hydroelectric installations have three basic types – storage or pondage plants (also known as "peaking" plants), "run-of-the-river" plants and pumped storage plants
- While hydroelectric developments do have some negative environmental impacts, control dams associated with hydroelectric stations have been shown to be effective in mitigating the effects of extreme weather conditions (flood and drought)
- Ontario has close to 200 operating waterpower facilities which account for about 7,700 MW of dependable generating capacity
- Many hydroelectric facilities provide fast-response (or spinning) reserve – power that is available instantaneously and without central control action to respond to emergencies or allowing the flexibility to "load follow" (or adjust to fluctuations in demand)

1.4.16 Provision for Managing Decommissioned Nuclear Generation and Spent Nuclear Fuel (From Part 3.7)

- *Federal Nuclear Fuel Waste Act, 2002*, (NWFA) established Nuclear Waste Management Organization (NMWO) to propose approaches for the management of nuclear fuel waste and implementing the approach that is selected and approved; commercial nuclear reactor owners support NWMO through regulated contributions other support
- NWMO issued a report in November 2005 on the alternative methods of long-term management in "Choosing a Way Forward – The Future Management of Canada's Used Nuclear Fuel"
- NWMO has assessed three technical options specified by the Nuclear Waste Management Organization (NFWA) – Deep Geological Disposal; Storage at Nuclear Reactor Sites and Centralized Storage – and added Adaptive Phased Management
- NMWO did not review appropriate role for nuclear power as part of this process
- Adaptive Phased Management was the recommended alternative – incorporation of social concerns was a strong driver in reaching this conclusion
- Canadian Nuclear Safety Commission (CNSC) was established in 2000 under the *Nuclear Safety and Control Act* to regulate operation, use and management of nuclear materials
- In 2005, CNSC issued a draft regulatory guide specifying that all nuclear facilities must have in place a decommissioning plan that conforms with detailed specifications
- Financial provisions respecting Ontario nuclear liability are contained in a consolidated guarantee to CNSC in the areas of decommissioning of Ontario nuclear facilities, nuclear waste management and a provincial guarantee for remaining costs. The total value of the guarantee to CNSC is $4.5 billion
- *Nuclear Liability Act* sets out required insurance, provision for risks covered by the operators, their insurance companies and the federal government

- Other countries are following somewhat similar paths in their methods of dealing with wastes, although the specifics of each country vary somewhat
- In November 2005, the NWMO recommended to the federal government, addition of the Adaptive Phased Management approach, which provides for deep, underground containment with the opportunity for retrievability at a future time

1.4.17 Integrated Gasification and Combined Cycle (IGCC) – Overview and Status (From Part 3.8)

- Integrated gasification of IGCC coverts organic feedstock (e.g., coal, biomass, etc.) to a synthetic gas which is burned in a conventional combined cycle plant; being a two-stage generation, IGCC is capable of achieving high efficiencies, in the range of 40-45%
- Use of multiple gasifiers allows IGCC to achieve high capacity factors because of the ability to do maintenance without plant shutdown
- Syngas has about 25% of the heating value of natural gas – meaning much more mass flow through the turbines is required
- IGCC uses a variety of means to reduce contaminant emissions: filters and water washing are used to remove particulates; mercury and other hazardous air pollutants can be removed by absorption using activated carbon; sulphur removal requires cooling the gas to below 100° C; and water/steam injection reduces NOx emissions
- Costs of emission controls are expected to decline by 90% as IGCC becomes widespread
- Dramatic reductions in carbon dioxide emissions are likely to become technically achievable and economically viable through sequestration; sequestration via enhanced oil recovery is already established, and can produce a revenue stream as well
- IGCC is cheaper (without sequestration and assuming an 80% capacity factor) than natural gas combined cycle for gas prices above $5 U.S./MMBtu and coal at $1.5U.S./MMBtu, but plant cost is 20-30% more than for pulverized coal plants
- Carbon dioxide capture and sequestration would add approximately 30 per cent to the capital cost and about 40 per cent to the cost of power, making it not competitive with natural gas at forecast prices
- Individual components of IGCC plants (except for carbon sequestration) have been widely used with petroleum residuals as fuel; little experience exists with integrated systems operating on coal and therefore it is not yet considered mature, reliable and economic
- Large-scale coal gasification with sequestration is not considered feasible or economic at this time
- It is more feasible to plan for small-scale gasification from biomass or waste for the to a 2015 timeframe, subject to ongoing monitoring of IGCC and sequestration experience in the U.S.

1.4.18 Context Background for Natural Gas Prices (From Part 3.9)

- Forecasting future natural gas prices is very difficult and uncertain, especially given the current tight supply environment in natural gas markets, uncertainty regarding liquefied natural gas (LNG) infrastructure and coalbed methane, and Ontario's plan to replace coal-fired generation
- Canadian gas reserves declined by 2% in 2003, which led to higher prices, but gas experienced a strong price recovery in 2004 even though production increased only slightly with a 43% increase in the number of wells drilled
- The most current National Energy Board estimate (2004) for the ultimate potential of natural gas in Canada, including proved reserves and undiscovered conventional resources (coalbed methane, tight gas and shale gas), is 575 Tcf, which is about 77 years of natural gas supply at 2002 levels of production
- OPA has selected the natural gas price forecast produced by Sproule— a recent forecast by an independent forecasting entity, for use in the preparation of the supply mix advice that projects that prices will decline from current levels to slightly less than $8/MMBtu by 2010 and remain close to this level until 2025. Other forecasts were reviewed and are generally consistent with Sproule's
- The OEB's Natural Gas Electricity Interface Review (NGEIR) reported that gas-fired generators would become the largest class of gas consumers in the province if all current coal-fired generation were replaced with natural gas, consuming more gas than all natural gas residential customers in the province combined
- The growth of natural gas-fired generation demand is not likely to conform to a steady load growth profile and hence there is likely to be additional demands on the delivery systems that have not previously been present
- The cost of infrastructure investment needed to accommodate such an expansion of gas-fired generation in Ontario could reach $815 million, depending on the increase in gas-fired generation, the location of the generators and their gas storage and deliverability requirements

1.5 Advice to OPA from Consultations

1.5.1 Introduction

The purpose of this section is to bring together all the advice for improving Ontario's electric industry that OPA has received since its inception earlier this year. Not only have there been consultations for supply mix advice, but also for other OPA initiatives, including York Region supply, generation procurement and the standard offer program. While the additional consultations were not specifically targeting supply mix issues, much of the advice reflected the significant challenges and options in planning supply and is therefore relevant to the exercise.

By setting out all the consultations together, this section also permits those interested in supply mix to see where the opportunities and challenges overlap. With respect to supply mix specifically, Section 2.3 of Volume 2 provides a detailed overview of the advice OPA received, including the names of all submitters and presenters, and Volume 5 (web posted) provides all the submissions and presentations.

Most of the advice received on supply mix responded to the government's objectives for additional conservation and demand management (CDM) and renewable energy resources. There were also recommendations on conventional sources, transmission and connection issues, education and training, planning approaches and approval issues.

In the following sections, we summarize the thoughts and opinions of the many members of the public and stakeholders who provided written submissions, made presentations, or otherwise communicated their positions on Ontario's electricity system through one or more of several consultations. The points below represent the opinions of interested parties, and not the OPA. Much of the advice received during consultations in the York Region, the generation procurement process and the standard offer program was mirrored by parties interested in the supply mix. An effort has been made to reduce the duplication of similar points and therefore some advice from other consultations may not be repeated if it was heard in supply mix.

1.5.2 Supply Mix Advice to OPA on CDM

On Residential Sector Codes and Standards, OPA heard advice that:

1. There should be a broad legislative and regulatory reassessment of appliance, housing and building codes and standards, including those for renovations, to align them with provincial CDM objectives and realizable best practices in the building industry
2. Measures should be taken to encourage switching from electric to natural gas appliances, and from electric to natural gas or solar water heating, where these options are available
3. A set of high-profile initiatives should be established to advance the outcome of the review of codes and standards, such as a "model green standard" or "Net Zero Housing Initiative"
4. Timelines and targets should be set for the eventual phase-out of appliances that do not carry the "Energy Star" rating

On Residential Sector Energy Efficiency, OPA heard advice that:

5. The resources of the Social Housing and Services Corporation and other agencies should be mobilized, with the help of province-wide programs including upfront incentives and CDM programs, for new social housing to incorporate energy efficient design standards and renewable energy applications
6. Administrative processes to assist landlords in implementing energy efficiency and conservation projects should be streamlined, including addressing the barriers (financial, education, information, institutional) to developing means to pay for energy-efficiency improvements
7. A public benefits charge should be applied as part of the uplift charges on the customers' bills to finance energy-efficiency improvements to social and low-income housing
8. The resources of the Social Housing and Services Corporation and other agencies should be mobilized to help deal with local supply challenges such as those that occurred in York Region

On Residential Sector Smart Meters, OPA heard advice that:

9. The implementation of smart meters should be designed to return the greatest benefit in the shortest period
10. Smart meter implementation should be sensitive to the needs of social housing where the resident's ability to shift load is constrained and where the implementation of individual metering (in place of bulk metering) can result in higher overall costs. Individual tariffs, where residents pay their bills directly rather than through their rents, could lead to an increase in customer defaults and disconnections

On Residential Sector Demand Reduction, OPA heard advice that:

11. The local distribution company (LDC) community, through their affiliates or other means, should come up with a plan for implementing residential load control programs for air conditioning and water heating
12. LDCs should be encouraged to work with the Conservation Bureau during the preparation of the IPSP to develop generic programs that could be implemented without requiring individual total resource cost (TRC) analysis in Ontario Energy Board (OEB) applications, which presumably would be attractive to LDCs and would encourage the creative development of effective, targeted programs
13. CDM programs of LDCs should be restricted only to customer CDM matters and promoting the "culture of conservation". It is recognized that some LDC CDM initiatives directed towards distribution system improvements, such as preventing line losses, do lead to positive results; however, alternative mechanisms should be considered for such efforts

On CDM Programs and energy services companies (ESCO) sector, OPA heard advice that:

14. Policies should be designed to re-stimulate the ESCO sector, including working with organizations like the Association of Municipalities of Ontario to provide assistance to the municipalities, Universities, schools and hospitals (MUSH) sector to understand the offerings of the ESCO industry
15. There should be a provincial "Better Buildings Partnership" (mirroring a similar initiative of the City of Toronto), developed with the input of the private sector, municipalities, and the broader public sector, to help building owners with CDM programs

On Commercial and Industrial Sector Demand Reduction, OPA heard advice that:

16. LDCs, within the parameters of approved CDM programs, should design programs that enable large retailers, especially those with locations in several LDC territories, to maximize the utilization of their resources by developing large scale demand reduction programs
17. A high-profile committee such as an "energy efficiency advisory committee" should be struck to develop tools to foster effective demand reduction and to investigate barriers
18. Incentives should encourage implementation of demand reduction programs for contracted air conditioning from commercial landlords, to facilitate more dispatchable demand reduction, and to provide additional incentives for businesses to make necessary investments in energy efficiency
19. Program incentives should be in place to encourage large commercial landlords to switch their downtown Toronto properties to deep lake water cooling and district heating systems
20. Policies should encourage and develop employee engagement programs in demand management and reduction
21. Programs and incentives should encourage the harvesting of energy from the shells of buildings (i.e. solar walls), possibly starting with demonstration projects

On Codes and Standards in the Commercial Sector, OPA heard advice that:

22. Programs are required to reduce payback times for energy efficiency upgrades for large office/commercial landlords to get over their payback hurdle, which is generally a three year payback period. Electricity is one of their largest controllable costs and many landlords do not have flexibility to push costs through to tenants
23. Building code standards should be applied to new builds and renovations in the office and commercial sectors, including lighting and cooling efficiency and ambient lighting criteria, as market forces can work against CDM objectives in these competitive sectors
24. Standards should be developed for a "Green Lease", similar to one developed by Public Works Canada, as a marketable product for landlords and office/commercial tenants that would permit businesses to distinguish themselves from others

On Local and Provincial CDM Programs, OPA heard advice that:

25. The IPSP should seek approval for large-impact CDM programs for province-wide implementation, so there is broad provincial approval and alignment through local implementation programs
26. The IPSP approval should be used to facilitate OEB pre-approval for LDC CDM programs such that the OEB would not need to rule on submissions for CDM programs from individual LDCs. However, if an LDC had a different, supplementary or additional program that it wished to pursue, it could still seek individual approval
27. The IPSP should have a list of approved projects so that each LDC does not have to justify the costs of approved programs
28. Templates of CDM programs should be provided to distributors based on the OEB's Total Resource Guide, which contains an "assumptions and measures" list that could be used by distributors in their TRC analysis for post-program evaluation

1.5.3 Supply Mix Advice to OPA on Renewable Energy

On Standard Offer Programs, OPA heard advice that:

29. Standard offer programs should be implemented for renewable energy sources such as wind power, waterpower, biomass and solar energy, where the connections are at distribution voltages
30. The connection costs for renewable energy resources should not be provided through cross-subsidies from a standard offer program's energy payments, but rather through pooled transmission and distribution costs to reasonable limits based on cost-benefit analysis and to ensure no cross subsidies between efficient and non-efficient connections

On Connection Policy for Additional Renewables, OPA heard advice that:

31. Additional assessments should be made of the costs and benefits for connecting the different wind power, waterpower, and other renewable energy sources based on their proximity to the transmission and distribution systems
32. Transmission and distribution connection studies for renewable generation should be conducted across the province to determine the most optimal additions to the transmission and distribution systems, to make the most of renewable resources and to reduce the risk to investors concerned about incurring costs and then not being able to proceed
33. There should be a review of the Transmission System Code and the Distribution System Code to permit pooling of extensions and connection costs for renewable energy resources
34. The costs for connecting renewables should be paid for as an uplift charge, borne by all those who would benefit from the resource, rather than disproportionately impacting the rate base of a transmitter or distributor
35. Any subsidies for renewables connection should be limited to a certain percentage to allow some price signals to encourage generation to be located in areas that have lower connection costs
36. Any impacts associated with adding connection assets for renewables to the rate bases of transmitters and LDC must be considered along with the ability of the utility to fund the operating, maintenance and administration associated with the assets

On Addressing the Integration of Additional Wind Power, OPA heard advice that:

37. System enhancements required to integrate additional wind resources in Ontario need to be assessed to determine the "load following" requirements from other generation resources
38. A review and assessment of system enhancements implemented in leading wind jurisdictions should be conducted to determine their applicability to Ontario
39. A study should be initiated to determine the feasibility of developing the infrastructure necessary to harvest the large volumes of wind energy located in the Hudson's Bay lowlands, and consideration should be given to the implications of developing these resources for route selection for the Manitoba interconnection and purchase from the Conawapa site on the lower Nelson River

On Addressing the Specific Needs of Waterpower Development, OPA heard advice that:

40. A permanent "window of opportunity" for new waterpower proposals, as opposed to intermittent opportunities with long interludes, should be opened to aid investors in the pre-development work required for "greenfield" waterpower opportunities
41. A single "one project, one process" approach should be considered for developing new or upgrading existing waterpower resources in Ontario
42. Current waterpower development exclusions in the far north, including restrictions on developments over 25 MW in the northern rivers and the Moose River Basin should be lifted

43. Adopting the notion of "working rivers", as understood in British Columbia for example, with a view to maximizing power development on specified rivers while prohibiting development on other rivers, should be explored in Ontario
44. The possibilities of siting additional pumped storage generation in Ontario should be assessed

On Addressing the Specific Needs of Solar Power Development, OPA heard that:

45. The feasibility and workability of feed-in tariffs (standard offers) for small quantities of renewables, particularly from solar generation systems, should be investigated
46. LDC affiliates and ESCOs should be encouraged to develop solar hot water applications, especially for commercial and institutional buildings
47. Consumer education should be provided on the safety protocols when installing solar collectors and the dangers of "guerrilla" installations for utility workers and homeowners
48. Consideration should be given to encouraging LDC affiliates to experiment with commercial solar collection schemes, possibly renting roof tops and building shells from the LDC's customers

On Addressing the Specific Needs of Biomass Development, OPA heard advice that:

49. The deficiencies in data on forest waste biomass to arrive at the economic potential for development need to be addressed
50. The possibilities for utilizing biomass energy from crop residues, anaerobic digestion from animal wastes, dedicated energy crops, landfill sites and wastewater treatment should be studied in detail

On Renewable Energy and First Nations Communities, OPA heard advice that:

51. The ability and feasibility of First Nations' communities taking advantage of permissible opportunities for developing wind power and waterpower sites within provincial park boundaries (as defined in Bill 11, the proposed Provincial Parks Act) should be assessed, especially where the size of the community is insufficient to support the financing and construction of the site without connection to the IESO-controlled grid
52. The framework for electricity supply in remote (off-grid) communities should be reviewed for impediments to advancing renewable energy sources as alternatives or as displacement to existing diesel-fired generation
53. The agreements with First Nations for the development of waterpower on the "northern rivers" rivers and the Moose River Basin should be acted upon

On Renewable Energy within Provincial Parks, OPA heard advice that:

54. It should be determined whether there are waterpower, wind power or other renewable energy sites within all the categories of provincial parks (e.g., wilderness, recreational, etc.) and whether they would be advantageous for development
55. Within the strictures and spirit of Bill 11 – the proposed Provincial Parks Act, an evaluation and cataloguing of alternative environmentally significant lands should be undertaken to determine if these lands could be exchanged for the preferred renewable energy sites

1.5.4 Supply Mix Advice to OPA on Conventional Resources

On Natural Gas-Fired Generation, OPA heard advice that:

56. There are significant concerns regarding the use of natural gas for supplying a significant component of new supply, including availability and price risks, constraints on deliverability and storage, procurement contracts and assignment of costs and allocation during scarcity, and the potential impacts on gas distribution tariffs from required gas infrastructure enhancements for new gas-fired supply
57. Using gas for a generation resource, especially for base-load requirements without being utilized in a CHP application, is an inefficient use of gas because of low conversion efficiencies in non-CHP applications
58. Gas is a highly suitable fuel for certain fuel cell applications

On Nuclear Power, OPA heard advice that:

59. The public should be protected from the cost of construction and operation and financial risk from development of nuclear technology
60. The integrity of existing nuclear sites should be maintained for future planning flexibility
61. The operational, technical and human infrastructure in the nuclear industry in Ontario should be retained for future planning flexibility
62. Ontario should not permit further refurbishments or new build nuclear plants because of the industry's poor financial and operating performance and because of the artificial benefit to the industry from the *Nuclear Liability Act*
63. New build nuclear programs should not be initiated before fully resolving nuclear waste and decommissioning issues
64. A centrally planned, fleet wide approach to sequencing nuclear refurbishments will be required to ensure proper planning, economies of scale, sufficient base-load capacity and the efficient use of resources
65. Planning for new nuclear in other countries looks ahead up to 50 years, as new build nuclear projects require sufficient planning to permit coordination among the parties involved, i.e. contractors, electricity system operator, nuclear operators, local communities,

licensing and approval bodies, and provincial and federal agencies such as the Canadian Nuclear Safety Commission and Nuclear Waste Management Organization (NWMO)

66. Should new build nuclear be pursued, a process should be established to assess and determine prospective sites, preferred technologies, and proponents, keeping in mind that there are municipalities in Ontario willing to be host communities for new nuclear plants
67. The provincial and federal governments should work together to develop a combined regulatory approval process for construction and operation of new build nuclear and possibly multiple site approvals

On the Coal Replacement, OPA heard advice that:

68. Alternatives to the existing coal plants would be challenging as these plants are critical for system operation and voltage support
69. The coal handling facilities and generation sites should be maintained with full integrity to ensure plants can be run if needed to address supply problems
70. There is no such thing as "clean coal" technology

On the Development of Fuel Cells, OPA heard advice that:

71. Fuel cell technology is currently expensive, but the cost relative to other energy sources is dependent on the application; fuel cells are ideal for small commercial and off-grid applications and for locations with wires constraints
72. The environmental signature of fuel cells is similar to renewables, the siting constraints are similar to distributed generation resources
73. Collaborative government policies are required to advance fuel cells commercially and to support research, development and demonstration of the technologies. Fuel cells should qualify to receive the federal power production incentive
74. Methane from wastewater plants and landfill could be captured and utilized for fuel cells

On Distributed Generation, OPA heard advice that:

75. Incentives should be considered for LDC affiliates to participate in the development of distributed generation resources, by looking for projects and bringing in developers

1.5.5 Supply Mix Advice to OPA on Education and Training

On Information, Education and Training, OPA heard advice that:

76. There should be an assessment of workforce demographics to determine the capacity and suitability of current higher education and training programs (apprenticeship, college, university and graduate education) to meet Ontario's future needs for the energy sector

77. The specific needs for providing the skilled workforce to implement CDM programs and renewable energy technologies and to replenish staff in the conventional generation sector, particularly nuclear, should be addressed and advanced through apprenticeship, college, university and graduate education programs
78. The curriculum in Ontario schools should incorporate greater awareness of the benefits of energy conservation and renewable energy resources
79. OPA's Conservation Bureau should be a "clearing house" for information on conservation and demand management and renewable energy sources

1.5.6 Supply Mix Advice to OPA on Municipal Issues

On Municipal Issues, OPA heard advice that:

80. Municipalities should have the same obligations for ensuring adequate electricity capacity as they do for the capacity of other utilities (water, sewer, etc.) before they approve development
81. The issue of whether a municipality could have the authority to set energy conservation and efficiency codes and standards higher than the provincial standard should be addressed
82. A process should be defined to resolve conflicts arising from circumstances where additional generation is required to service a community but the community does not want to host the generation resource
83. Provincial standards should be developed with respect to a "local option" for transmission appearance or underground lines, including mechanisms for cost sharing for options above the least cost option, with lowest cost option in the transmission pool and improved appearance and under-grounding differentials being paid by local communities or municipalities

1.5.7 Supply Mix Advice to OPA on Connection and Siting Issues

On Using Transmission to Facilitate a Generation Market, OPA heard advice that:

84. A minimal constraint transmission policy should be developed to ensure system reliability and lowest-cost generation development act as a facilitative tool similar to the "Alberta model", which was the historic policy in Ontario
85. Transmission ought to be considered a basic public infrastructure which is built ahead of generation
86. Consideration should be given to adopting the Federal -Provincial-Territorial Radiation Committee's recent "position statement" (January 2005) on precautionary measures for EMF (electromagnetic fields) to address community concerns and resolve planning uncertainty for developing and redeveloping transmission corridors

87. The logic of "smart growth" municipal planning principles should be adapted to electric power planning objectives to "maximize use of existing infrastructure", allow "brownfield" sites advantages over "greenfield" sites and to permit reasonable additions to existing sites without excessive assessment hurdles
88. The primacy of transmission on all existing and future corridors should be enshrined to relieve "brownfield" corridors from the same environmental and public scrutiny requirements as development of "greenfield" corridors and to favour additional transmission line and infrastructure development on existing rights-of-way
89. The Ontario Energy Board should give consideration to requiring approval of associated transmission with approval of generation projects, and the IPSP should seek approval for transmission siting based on planned requirements
90. Electricity distributors would like templates and standard generic agreements to facilitate the applications process for connecting distributed generation
91. Technical guides could assist distributors in assuring the requirements for connecting distributed resources, protecting the distribution system and meeting safety requirements are achieved, while also considering the cost to the generation owner
92. Consideration should be given to permitting transmission tariff cost recovery concurrently with approval and development of critical projects to overcome regulatory lag

1.5.8 Advice to OPA from Generation Development Stakeholder Consultation

On the Procurement Process for New Generation Projects, OPA heard advice that:

93. Bid security requirements should be more flexible with respect to smaller projects, by security obligations to the relative size of projects and resources of bidders or by linking security to the stage of the process
94. The bid financing requirements should be simplified by having standard language provided for financing commitment letters and allowing more debt to be used in financing proposed generation projects
95. The buyer should be able to ask follow-up questions of the bidder during the bid development phase, possibly in an open forum, to facilitate the exchange of ideas and information between OPA and potential bidders
96. Anti-collusion restrictions should be made less strict to allow for some access to providers of key services, where there may be only one or a few sources of critical components and support elements available to small proponents, and where the restrictions limit opportunities for developing synergies
97. Longer, twenty year-plus contract terms would facilitate more competitive financing arrangements and increase confidence about process stability
98. Contract terms for procuring new generation should be more flexible to allow changes in the proponent team earlier in the project life cycle and to permit transfer of the

contractual arrangement to another party in some cases, and be simplified to reduce risk and legal requirements for prospective facility owners

99. A pre-qualification phase for RFPs should be introduced, with provisions to ensure small and community-based stakeholders are not excluded, to evaluate the qualifications of the development team and their ability to see the project through to completion
100. The breadth of final project evaluation criteria should be broadened from economics to include quantitative and qualitative attributes of each particular project, such as the value of thermal energy, environmental attributes, avoidance of transmission congestion, job creation/retention, etc.

On Additional Issues Specific to CES, OPA heard advice that:

101. Changes in the clean energy supply (CES) contracts should encourage the development of a competitively priced forward contracts market, perhaps by allowing generators to opt-out of the CES contract or by offering other incentives for generators to add value by participating in and developing a forward contracts market
102. CES contracts should allow for multiple daily starts so that operators can recover their true costs and reduce uncertainty in their bids

On Additional Issues Specific to CHP, OPA heard advice that:

103. The time frame for responding to combined heat and power (CHP) RFPs should be more flexible to account for the normally longer times required to negotiate agreements with steam hosts
104. The RFP processes for CHP projects should be simplified to expand the range of projects and the potential number of participants in the RFPs

On Additional Issues Specific to RES, OPA heard advice that:

105. The fuel and generation types that qualify as renewables for the procurement process should be broadened to include the full range of renewable energy sources available
106. There should be more flexibility in the security and financial requirements for renewable energy supply (RES) projects, to allow small-scale and community-based developers more eligibility in the RFP process for RES

On Additional Issues Specific to CDM, OPA heard advice that:

107. Smart Meters would be essential for effective deployment of CDM projects
108. CDM projects should be treated separately from other procurement processes due to CDM's unusual characteristics
109. Audit procedures and other monitoring and verification standards for CDM projects should be established to ensure consistency and deliverability of CDM

110. LDCs should manage and implement the operation of the network up to the meter, and beyond the meter, the consumer should determine how best to take advantage of the information provided to respond to price signals, within a consistent CDM framework across the province
111. Contracts specific to CDM projects should be developed. They should be performance-based, more flexible in length, and have simpler terms, which will reduce risks to facility owners and service providers
112. Time to respond to CDM RFPs should be more synchronous with the time required to sign customers onto CDM programs

1.5.9 Advice to OPA from York Region Consultation

On Planning Approaches, OPA heard advice that:

113. There should be continuous monitoring of demand in regional areas and extrapolation of demand to determine when a decision point has been reached to trigger a major development project
114. There should be a stronger link between municipal development and electricity system planning so that when subdivisions are developed there is available supply, and developments can be turned down due to insufficient power
115. Policies relating to land uses adjacent to transmission right of ways should be created to ensure that homes are not built too close to transmission lines
116. Communities responsible for consuming the vast quantity of electrical power should be responsible for its production

On Additional Issues Specific to CDM, OPA heard advice that:

117. Financial incentives to identify energy leaks in industrial systems or to redesign processes to use less electricity should be implemented
118. The Transitional Demand Response Program should be expanded and properly promoted to embedded loads
119. The provincial 5% CDM target for 2007 is not sufficient for the affected area in York Region and CDM activities should target reductions beyond the 5% provincial target
120. The types of CDM initiatives to be pursued in York Region should be more specific; with a greater emphasis on CDM in future plans, it is not sufficient to lump CDM together as a single category
121. Linking LDC profits to customer bill-reductions resulting from CDM should be the model employed to make customers more energy efficient and to promote conservation
122. The potential for conservation in York Region should be thoroughly assessed, then a plan must be developed to identify objective targets, measurable timelines and to assign responsibility for ensuring these goals are achieved

On Additional Issues Specific to Evaluation Factors, OPA heard advice that:

123. Evaluation factors within OPAs mandate should be revised to capture all important factors that need to be considered when evaluating different options (generation, transmission, etc.) including environmental factors

On Additional Issues Specific to the Transmission Lines, OPA heard advice that:

124. A study should be conducted to reduce the costs of underground cabling through boring by identifying the major cost components and to determine methods to reduce costs
125. Federal and provincial officials should establish standards for electromagnetic fields that would apply to electricity system projects and to the private sector
126. The benefits of transmission lines on downstream facilities such as transformer station location and feeder costs for distribution utilities should be considered, even if they are outside the study area, as ratepayers ultimately pay the cost of proposed solutions from generator to meter base

1.5.10 Advice to OPA from Standard Offer Consultations

On Eligibility in General, OPA heard advice that:

127. A standard offer program with unified terms and conditions should be applied to RES, CES, CDM and CHP projects
128. The standard offer contract (SOC) should be a mechanism that encourages sustainable investment in the province of Ontario that is consistent with broader energy planning objectives

On the issue of Ownership and Eligibility, OPA heard advice that:

129. Ownership of projects should not be restricted
130. Proponents should be required to demonstrate widespread support for community involvement in projects in order ensure community acceptance and to encourage further optimization of local economic, social and environmental benefits
131. Ontario Power Generation (OPG), LDCs and LDC affiliates should not be permitted to participate as project owners
132. Specific recognition of First Nations involvement should be perceived as adding value to certain projects

On the Issue of Fuel Source/Eligibility, OPA heard advice that:

133. No fuel type should be excluded provided it was defined as renewable under the RES RFPs
134. Fuel source is relevant to the price premiums and the economic valuation of promoting particular fuels to broaden further public policy objectives

On the Issue of Size Limits/Eligibility, OPA heard advice that:

135. There should not be a cap on the amount of total power acquired under the program in the interest of capturing as much renewable generation as possible
136. Let LDC interconnection constraints determine program limits; limitations on a per owner basis would be impractical
137. Let technologies determine size: for example, there would only be a certain amount of wind power available for a given location

On the Issue of Location/Eligibility, OPA heard advice that:

138. LDCs should allow non-discriminatory access to the grid, providing that the capacity exists
139. Areas of congestion should receive priority, provided those proponents have demonstrated site control
140. The contract should permit flexibility and not dictate specific interconnection and metering requirements
141. The standard offer program, in addition to encouraging use of renewable generation, should be designed as a mechanism for bringing economic renewal to certain areas such as disadvantaged rural and First Nation regions

On the Issue of Pricing, OPA heard advice that:

142. The tiered pricing structure outlined by the Ontario Sustainable Energy Association is appropriate for wind projects
143. Adoption of a cost-based pricing structure paid on a $/MWh energy output, with a basis or premium attributed for different technologies, is widely supported because no one price would be appropriate for all technologies
144. Pricing should ensure a 10-12% rate of return on investment, with the operating and maintenance portion of costs escalated at the Consumer Price Index
145. Where incentives such as Wind Power Production Incentive (WPPI) exist, discrimination between large and small projects should not be perpetuated; incentives for renewable energy should also be applied to standard offer program eligible ones as well
146. There is uncertainty regarding incentives for providing peak vs. non-peak energy supply
147. There is disagreement on who should take fuel price risk: the proponent or the buyer
148. Payment to an LDC in the amount of 1¢/kWh to facilitate the wheeling of power through a distribution system within a defined geographic distance should be permitted

149. Pricing should be kept simple, flexible, fully transparent, with the option for periodic review, and not so high as to promote excessive profit making
150. The upper ceiling price paid for renewable energy should be the avoided cost of imported power

On the Issue of Terms and Conditions, OPA heard advice that:

151. Terms and conditions should be kept simple and straightforward to reduce administrative burden and encourage widespread participation
152. Terms should include certainty and guaranteed access to the grid for the duration of the contract term
153. Environmental issues should continue to be governed and monitored
154. Hoarding should be prevented by a two-year window between the awarding of a contract and the time that facilities are commissioned and brought on-line. There should also be a requirement for demonstration that environmental assessments and interconnections are in place or underway
155. OPA should be the contract signing counterparty, not the LDC
156. Terms should be flexible in order for some renewable generators to meet permitting and approvals for projects involving First Nations or Crown territories
157. Periodic review of long term contracts should be allowed to accommodate for changes in legislation

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1.6 Glossary of Terms

Acid rain	Precipitation containing nitric and sulfuric acids formed primarily by sulfur dioxide and nitrogen oxides released into the atmosphere by the burning of fossil fuels.
Advanced coal technologies	Technologies designed to enhance both the efficiency and environmental acceptability of coal extraction, preparation, and use.
Aggregators	Companies that buy or broker electricity on behalf of contracted retail customers. They may also offer capacity for demand response to the market.
Alternating current (AC)	An electric current that reverses its direction at regularly recurring intervals.
Ancillary service	Functions required to support the reliable operation and security of the transmission and generation system. They are coordinated by the IESO and include various types of operating reserves and spinning reserve, frequency and voltage control and black-start capability.
Appliance	Ordinarily self-contained equipment powered by electricity that is used to perform an energy-driven function. Common appliances include refrigerators, clothes washers, conventional ranges/ovens and microwave ovens, toasters, radios, and televisions. Not included in this definition are central heating or cooling components.
Appliance efficiency standards	Specifications that set prescribed minimum energy efficiency of classes of appliances (may be voluntary or mandatory).
Average weather	The average temperature, humidity, wind speed, cloud index, etc, for a given day, month or year.
Backup generator	A generator used in the event of an emergency, such as a power shortage, to meet customer load requirements.
Backup power	Electric energy supplied by a utility to replace power and energy lost during an unscheduled equipment outage or when the power to meet demand is not available.
Base load	The minimum continuous load over a given period of time.

Base-load plant	A plant which is normally operated continuously and at a constant rate, to meet all or part of the minimum load of a system.
Bilateral electricity contract	A direct contract between an electric power producer and either an end-user or broker acting on behalf of an end-user.
Biomass	Organic non-fossil material available on a renewable basis, as long as the rate of extraction is equal to or less than the rate of replenishment. Biomass includes plant fibre such as wood, agricultural waste, manure, and other living-cell material that can be burned to produce heat energy.
Bottoming cycle	The process of recovering waste-heat to produce steam in a boiler, capturing the unused energy to drive a steam turbine generator to produce electricity.
Capacity	The maximum power output for which a generating unit, generating station or electricity producing apparatus is rated. Common units include kilowatts (kW), megawatts (MW) or gigawatts (GW). Also used to refer to the maximum potential output for the entire electricity system.
Capacity factor	The ratio of the electrical energy produced by a generating unit for a period of time to the electrical energy that could have been produced at continuous full power operation during the same period. It is usually expressed as a percentage.
Carbon dioxide (CO_2)	A colorless, odorless, non-poisonous gas naturally occurring in the Earth's atmosphere, and as a by-product of fossil fuel combustion. CO_2 is a greenhouse gas as it traps heat (infrared energy) radiated by the Earth into the atmosphere and thereby contributes to the potential for global warming. The global warming potential (GWP) of CO_2 is assigned a value of 1, and it is the gas by which the GWP of other greenhouse gases is measured.
Carbon dioxide equivalent (CO_2e)	A metric measure used to compare the emissions from various greenhouse gases based upon their global warming potential (GWP). Carbon dioxide equivalents are expressed as tones of carbon dioxide equivalents (tones CO_2e), and may be expressed in relation to other metrics, such as megawatt hours of electricity. The carbon dioxide equivalents for other gases are found by multiplying tones of the gas by its associated GWP.

Climate change	Refers to all forms of climatic inconsistency, particularly with respect to significant change from one prevailing climatic condition to another. The term has been used synonymously with the term "global warming.", but scientists also use climate change to refer to natural changes in climate.
Coal	A readily combustible black or brownish-black rock whose composition, including inherent moisture, consists of more than 50 percent by weight and more than 70 percent by volume of carbonaceous material. It is formed from plant remains that have been compacted, hardened, chemically altered, and metamorphosed by heat and pressure over geologic time. Ontario does not have significant deposits of coal and therefore coal used for electricity generation is imported from the United States or western Canada.
Coal gasification	The process of converting coal into a synthetic, combustible gas or “syngas”. The process involves heating pulverized coal in the presence of steam and oxygen to produce gas, which is then refined to reduce sulfur and other impurities. The gas can be used as a fuel or processed further and concentrated into chemical or liquid fuel.
Cogeneration	The combined production of electricity and useful heat from a single fuel source. Heat produced to generate electricity can be used at industrial plants in manufacturing processes and for general space heating as well as for space heating and cooling in urban residential developments. Cogeneration facilities use significantly less fuel to produce electricity and thermal energy than would be needed to produce these products separately.
Combined cycle plant	An electricity generating station that uses waste heat from its gas combustion turbines to produce steam that drives conventional steam turbines for further production of electricity. This process increases the efficiency of the generating unit.
Combined heat and power (CHP)	See cogeneration.
Congestion (transmission)	A condition on a transmission or distribution system that occurs when insufficient transmission capacity is available to implement all of the preferred schedules simultaneously or when the load on a transmission line exceeds that line’s capacity to supply the power.

Commercial sector	An energy-consuming sector that consists of non-manufacturing and service-providing facilities and equipment of businesses; federal, provincial and municipal governments, and organizations such as religious or fraternal groups. The commercial sector includes institutional living quarters. Common uses of energy associated with this sector include lighting, space and water heating, air conditioning, refrigeration, cooking, and running a wide variety of other equipment.
Conservation and demand management (CDM)	The planning, implementation and monitoring of activities designed to encourage consumers modify their level of demand or shift their demand from on-peak to off-peak periods. CDM activities refer only to activities taken in response to programs or interventions, and not energy and load shape changes arising from normal stock turnover. Categories of CDM include conservation, energy efficiency, load shifting, and demand response.
Conservation	Any activity which reduces the amount of electricity used overall, either by using more efficient technologies or by changing habits.
Conservation decrement profile	The variation in the magnitude of the conservation impact over a daily, weekly or annual period based on normal weather.
Consumer (energy)	Any individually-metered dwelling, building, establishment or location using electricity.
Conventional thermal generation	Electricity generated by an electric power plant that consumes non-renewable fuels such as coal, petroleum, gas or nuclear material as its source of energy.
Demand response (DR)	Reduction in electricity use in response to peak pricing or under contract with a system operator (such as the Independent Electricity System Operator). DR serves to balance supply and load in a short amount of time.
Demand side management (DSM)	Another term for the class of activities known as conservation and demand management. See conservation and demand management.
Deterministic Analysis	Methods of analysis or modeling techniques which assume conditions of certainty for input variables. These methods assume only one possible result for each alternative.
Direct current (DC)	Electric current in which electrons flow in one direction only. Produced by solar PV and some wind generation sources, as well as batteries.

Direct load control	Program activities that can interrupt customer load at the time of seasonal peak load by direct control of the power supply to individual appliances or equipment on the customer's premises. This function is normally carried out by the system operator and usually involves residential customers.
Dispatch	The process by which a system operator, such as the IESO, directs the real time operation of a supplier or a purchaser to cause a specified amount of electric energy to be provided to or taken off the system.
Dispatchable	A Generator or Load that is capable of responding to real-time control from a system operator such as the IESO.
Distributed generation (DG)	Electricity generating capacity located close to the customers it serves.
Distribution	The delivery of energy to retail consumers connected to the low-voltage (50kV or less) power system.
Distributor	Any entity that owns and is responsible for the maintenance of local distribution network systems that connect the bulk transmission grid to the end-use customer.
District heat	Steam or hot water produced in a central co-generation plant is piped into buildings as an energy source.
Diversity of supply	Spreading of risk by placing assets in several categories of (generation) investments or within a broad range of resources in one portfolio.
Dual-fired unit	A generating unit that can produce electricity using two or more input fuels.
Effective Capacity	Generation capacity available to meet demand during peak use periods.
Electric power	The rate at which electric energy is transferred, measured in capacity and commonly expressed in kilowatts (kW) or megawatts (MW)
Electricity Restructuring Act (Bill 100)	Provincial legislation, enacted in 2004, which created the Ontario Power Authority, and redefined the roles and responsibilities of the Independent Electricity System Operator and the Ontario Energy Board.
Electricity generation	The process by which electrical energy is produced by transforming other forms of energy. Electric energy is commonly expressed in kilowatthours (kWh) or megawatthours (MWh).

Electricity intensity	The amount of electricity consumed per unit economic output (such as Gross Provincial Product or Gross National Product) for a given period of time.
Electricity productivity	The amount of economic output (such as Gross Provincial Product) per unit electricity consumed for a given period of time. The inverse of electricity intensity.
Electricity wholesale market	Wholesale electricity markets are comprised of transactions between buyers and sellers of bulk power from the high-voltage transmission system. Sellers in the wholesale market do not sell electricity to end-users such as residential or commercial customers, but to large volume consumers who are directly connected to the transmission system. The wholesale market operates as a spot market in Ontario which continuously balances supply and demand.
Emission	A release or discharge of a substance into the environment. Typically refers to substances having potentially negative impacts on the environment.
Energy carrier	Any system or substance used to transfer energy from one place to another. Electricity and hydrogen are energy carriers.
Energy efficiency (electricity)	Refers to programs, technologies and measures that reduce the energy used by specific end-use devices and systems without affecting the quality of services provided. Overall electricity consumption is reduced often without explicit consideration for the timing of program-induced savings.
Energy Services Corporation	A company that offers to reduce a client's utility costs, often with the cost savings being split with the client through an energy performance contract or shared savings agreement.
Extreme weather peak demand	The annual peak demand incurred in a year with one or more periods of extreme weather. The weather incurred in the summer of 2005 would be an example of extreme weather. In 2005, the previous record for peak demand (25,414 MW set in August 2002), was exceeded on seven separate occasions.
Fuel	Any material substance that can be consumed to supply heat or power, including coal, oil, natural gas (fossil fuels), uranium, biomass, syngas or hydrogen.

Fuel cell	A device capable of generating an electrical current by converting chemical forms of energy (e.g., hydrogen, methanol) directly into electrical energy. Fuel cell generation does not contain an intermediate heat cycle, as with most other electrical generation methods.
Generator	An entity that owns or operates an electricity generating plant.
Gigawatt-hour (GWh)	One million kilowatt-hours
Global warming potential (GWP)	The ratio of the warming caused by a substance to the warming caused by a similar mass of carbon dioxide. Methane (CH_4) has a GWP of 23 and nitrous oxide (N_20) has a GWP of 296, as agreed by the International Panel on Climate Change.
Greenfield investment	An investment in a new generation or transmission facility that is located on new site.
Grid	A network of electric power lines and connections.
Head	The usable difference in elevation that water falls in a hydroelectric plant in transferring its energy to a turbine generator.
Hourly Ontario Energy Price (HOEP)	The hourly average of the uniform Ontario energy prices in the Ontario Electricity Market, determined for each five minute dispatch interval as published by the IESO for the settlement hour.
Hydroelectric generation	Also referred to as waterpower, hydroelectric generation relates to electricity generated by moving water. Hydroelectric power is produced in three main variations: impoundment, run-of-river and pumped storage generation. **Impoundment**: Generation involving the installation of a dam and creation of a reservoir including some amount of flooding. Water release for generation may be based on demand or for the maintenance of water levels downstream. **Run-of-river**: Also referred to as diversion. It is generation where water is not impounded into a reservoir, instead it is diverted from the natural water course and passes through some form of channel and through a turbine. **Pumped storage generation**: Water is pumped from a lower reservoir to an upper reservoir based on energy demand. Water is generally pumped uphill during periods of low demand and released during periods of high demand and higher electricity cost. This type of installation does not always involve the creation of a damned reservoir.

Hydro One Networks	A company established by the *Ontario Electricity Act 1998*, whose principal business is the transmission and distribution of electricity in Ontario and to interconnected markets. It is 100% owned by the Province of Ontario.
IESO-controlled grid	The transmission systems in which the IESO has authority to direct operations.
IESO market rules	Rules administered by the IESO, setting forth the terms and conditions for the operation of the marketplace. They include operating rules, rules for dispute resolution and connection requirements, among others.
Independent Electricity System Operator (IESO)	A non-profit, regulated corporation established by the *Ontario Electricity Act 1998*. Its roles involve overseeing the operation of the Ontario wholesale electricity market and managing the reliability of the high-voltage power system.
Industrial sector	An energy-consuming sector consisting of facilities and equipment used for producing goods, extraction and processing of natural resources including mining and forestry and construction.
Installed capacity	The sum total of the nameplate capacity of all generating stations connected to the grid, usually expressed in MW or GW.
Interconnected system	Two or more individual transmission systems that have one or more interconnecting tie lines.
Integrated resource planning (IRP)	A planning process that evaluates full ranges of alternatives, including new generating capacity, power purchases, energy conservation and efficiency, cogeneration and district heating and cooling applications and renewable energy resources. IRP can be thought of as a process of planning to meet users' needs for electricity (and energy) services in a way that satisfies multiple objectives for resource use.
Intermediate generation	Process of producing power for substantial periods of time, but not full time. Typically, intermediate generating plants run about 8-16 hours each day during peak hours. Examples can include coal-fired generation, waterpower and combined-cycle gas turbine generation.
Intermittent resource	An electric generating plant with output controlled by the natural variability of the energy resource rather than dispatched based on system requirements. Intermittent output usually results from the direct, non-stored conversion of naturally occurring energy fluxes such as solar energy, wind energy, or sometimes the energy of free-flowing rivers (i.e. run-of-river hydroelectricity).

Interruptible load	Energy made available under an agreement that permits curtailment or interruption of delivery at the option of a supplier or system operator.
Intertie	A transmission line that interconnects two adjacent transmission systems, such as those of Ontario and New York State.
Inverter	A device used to convert direct current electricity to alternating current.
Kilowatt (KW)	1,000 watts (W) or 1.34 horsepower (hp).
Kilowatt-hour (KWh)	The amount of electrical energy produced or consumed by a one-kilowatt unit for one hour (1,000 watt hours).
Kyoto Protocol	The result of negotiations at the third Conference of the Parties in Kyoto, Japan, in December, 1997. Canada has signed and ratified the Kyoto Protocol agreeing to binding greenhouse gas emissions targets of 5% below 1990 levels for the anthropocentric emission of carbon dioxide, methane, nitrous oxide, hydrofluorocarbons (HFCs), perfluorocarbons (PFCs) and sulfur hexafluoride.
Landfill gas	Combustible gas composed of about half methane and half carbon dioxide and water by volume, produced by the decomposition of organic material at landfill disposal sites. The methane gas can be collected and burned to produce electricity.
Lay-up	The status of equipment (such as a power plant) that has been placed in storage ("mothballed").
Levelized cost	Also known as “levelized unit electricity cost” or LUEC, it is the present value of the total cost of building and operating a generating plant over its economic life, converted to equal annual payments, levelized in real dollars (i.e. discounted to remove the impact of inflation).
Line loss	The energy lost in circuits or equipment mainly in the form of heat, when current flows through circuits. Line losses are typically higher when electricity is transported over longer distances through transmission and distribution systems.
Load	The amount of electric power or natural gas volume delivered or required at any specific point or points on a system. The requirement originates at the energy-using equipment of the consumer.
Load curve	The relationship of power supplied to the time of occurrence. It illustrates the varying magnitude of the load during the period covered.

Load following	Regulation of the power output of electric generators within an area in response to changes in system frequency, demand, or the relation of these to each other. Load following maintains the scheduled system frequency and/or established interchange with other areas within predetermined limits. It is the process by which the system operator meets variations in electricity demand.
Load Serving Entity	An organization that supplies electricity to others. In Ontario, the local distribution companies also provide this function.
Load shedding	Intentional action by a utility that results in the reduction of firm customer load for reasons of limiting interruptions of service on a wider scale.
Local distribution company (LDC)	An entity that owns a distribution system for the local delivery of energy (gas or electricity) to consumers.
Marginal energy cost	The sum that has to be paid for the next increment of product or service; for example, the marginal cost of electricity is the price to be paid for each kilowatt-hour above and beyond the power supplied by currently operating generation capacity.
Market clearing price (MCP)	The price at which a market clears, such that there are no further gains to be made from further trading.
Megawatt (MW)	1,000 kilowatts (kW) or one million watts (W). Unit of electrical power commonly used to measure the capacity of a generating station or the maximum demand of a large electricity consumer.
Megawatt-hour (MWh)	A measure of the energy produced by a generating station over time; 1 MW of power produced for 24 hours provides 24 MWh of energy (as does 24 MW produced for one hour).
Meter	Equipment that measures and registers the amount and direction of energy quantities over a period of time.
Methane	A colourless, flammable, odorless hydrocarbon gas (CH_4) which is the major component of natural gas. It is also an important source of hydrogen in various industrial processes. Methane is a greenhouse gas with 23 times the global warming potential of carbon dioxide.

Monte Carlo simulation	A statistical technique for producing estimates of outcomes of stochastic (random or unpredictable) processes by running many iterations of the model process and averaging the outcomes together. Results are given as statistical indicators, such as a mean and standard deviation, of variable X.
Name plate	A metal tag attached to a machine or appliance that contains information such as brand name, serial number, voltage, power ratings under specified conditions, and other manufacturer supplied data.
Nameplate capacity	The maximum power rating of a generating unit, usually expressed in megawatts (MW) or kilowatts (kW).
National Energy Board (NEB)	The federal regulatory agency in Canada that authorizes oil, natural gas, and electricity exports; certifies inter-provincial and international pipelines and designated power lines; and sets tolls and tariffs for oil and gas pipelines under federal jurisdiction.
Non-governmental organization (NGO)	A not-for-profit group or association outside of institutionalized political structures which is focused on non-commercial issues, such as environmental protection. NGOs may be partly funded by governments. NGOs include lobbying groups, trade associations, volunteer associations, faith-based organizations, and others.
Non-utility generators (NUGs)	Generators owned by entities other than an electric utility. Also referred to as Independent Power Producers (IPPs).
Normal weather	Analogous to average weather.
Normal weather peak conservation impact	The impact of conservation on the normal weather peak demand.
Normal weather peak demand	The annual peak demand assuming each day within the calendar year is characterized by normal weather conditions (consistent with the IESO 10-Year Outlook).
North American Electric Reliability Council (NERC)	A council formed in 1968 by the electric utility industry to promote the reliability and adequacy of bulk power supply in the electric utility systems of North America. NERC consists of regional reliability councils and encompasses essentially all the power regions of the contiguous United States and Canada.
Nuclear power	Power generated at a station where the steam to drive the turbines is produced by a nuclear fission reaction, rather than by burning a combustible fuel such as coal, oil or gas.

Nuclear reactor	A nuclear reactor includes fuel (fissionable material), moderating material to control the rate of fission, a heavy-walled pressure vessel to house reactor components, shielding to protect personnel, a system to conduct heat away from the reactor, and instrumentation for monitoring and controlling the reactor's systems.
Off-peak period	The period of time during a day, week, month or year when electricity use on a particular system is at a relatively low level.
Ontario Electricity Financial Corporation (OEFC)	A statutory, non-share capital corporation and the legal continuation of Ontario Hydro. OEFC retains services from the Ontario Financing Authority (OFA) and the Ministry of Finance to carry out its daily operations. The OFA is the agency of the Province of Ontario responsible for provincial borrowing and debt management activities. The OFA manages OEFC's debt, derivatives and non-utility generator (NUG) portfolios, and provides cash management, accounting and other financial services and support to the corporation. The Ministry of Finance manages the collection and reporting of payments-in-lieu of taxes on behalf of OEFC.
Ontario Energy Board (OEB)	A regulatory agency of the Ontario Government. It is an independent, quasi-judicial tribunal created by the *Ontario Energy Board Act*. Although it reports to the Legislature through the Minister of Energy, the Board operates independently from the Ministry and all other government departments in the performance of its regulatory functions and responsibilities.
Ontario Power Generation (OPG)	A company established by the *Ontario Electricity Act 1998*, whose principal business is the generation and sale of electricity to customers in Ontario and interconnected markets. It is 100% owned by the Province of Ontario.
Operating reserve	The amount of generation that is immediately at hand to offset an unexpected loss of supply.
Particulate material (PM)	A class of small, discrete masses of solid or liquid matter that remain individually dispersed in gas or liquid emissions. Particulates take the form of aerosols, dust, fumes, mist, smoke or sprays, each having different properties. $PM_{2.5}$, or the class of particles less than 2.5 microns in diameter, are considered to be of most public health concern.

Peak-use period	The period of time when gas or electricity use on a particular system is at or near its maximum and when supply is most likely to be suspended for interruptible service customers.
Peaking capacity	Capacity of generating equipment normally reserved for operation during the hours of highest daily, weekly, or seasonal loads. Some generating equipment may be operated at certain times as peaking capacity, typically natural gas or hydroelectric facilities.
Peat	Partially decomposed plant debris. It is considered an early stage in the development of coal. Peat is distinguished from lignite by the presence of free cellulose and a high moisture content (exceeding 70 percent). Peat can be burned on its own or co-fired with coal to generate electricity.
Photovoltaic (solar)	A means of converting solar energy into direct current electrical energy (typically by way of photovoltaic cells, or panels comprising a number of cells).
Power	The rate of producing, transferring, or using energy, most commonly associated with electricity. Power is measured in watts and often expressed in kilowatts (kW) or megawatts (mW). Also known as active power.
Public utility	An organization that provides basic services to the public, such as water, energy, transportation, or telecommunications.
Rates	The authorized charges per unit or level of consumption for a specified time period for any of the classes of utility services provided to a customer.
Real time pricing	The price set every five minutes in the wholesale market by the interaction of supply and demand.
Rectifier	A device for converting alternating current to direct current.
Regulator	An entity that, through power of law or some other legitimate means, has the authority to impose regulation.
Renewable energy sources	Energy sources that are renewed by natural processes including wind, biomass, solar, geothermal, water, and tidal.
Renewable portfolio standard (RPS)	A target that is established for the amount of renewable generation in the supply mix.
Request for proposal (RFP)	A process for obtaining competing proposals from providers of a service or product.

Reserve generating capacity	Amount of generating capacity available to meet peak or abnormally high demands for power and to generate power during scheduled or unscheduled outages.
Reserve margin	The amount of generation capacity that must be available to meet reductions in supply.
Residential sector	The energy-consuming sector consisting of living quarters for private households. Common uses of energy associated with this sector include space heating, water heating, air conditioning, lighting, refrigeration, cooking and running a variety of other appliances. The residential sector excludes institutional living quarters.
Retail market	A market in which electricity and other energy services are sold directly to consumers by competing suppliers. Also known as retail access or direct access.
Simple cycle generation	A manner of electricity production involving natural gas being combusted in a simple cycle gas turbine (SSGT), where waste heat generated by the process is not captured or used.
Smart meter	A generic term for any meter capable of measuring both the amount of electricity consumed and the time at which it was consumed. Some smart meters may have additional capabilities.
Solar energy	The radiant energy of the sun that can be converted into other forms of energy, such as heat (e.g. for water heating) or electricity.
Solar thermal	A device designed to receive solar radiation and convert it to thermal energy. The heat collected by the solar collector may be used immediately or stored for later use. Solar collectors are used for space heating, domestic hot water heating, heating swimming pools, hot tubs, or spas.
Spot market	A market in which goods are traded for immediate or near-immediate delivery. In the IESO administered electricity market, bids to buy or sell electricity determine a market clearing price.
Spot market prices	The market clearing price determined in a spot market and used as the basis of settlements for all purchases and sales in that market.
Standby facility	A facility that is generally running under no-load or as no-load spinning reserve, which is able to react to rapid increases in demand or to plant outages.

Stepped rates	Rate structure where the unit price rises with consumption in a stepped fashion. For example, in 2005 most Ontario residential consumers will pay a stepped rate of 5 cents on the first 1,000 kWh of consumption (wintertime) and 5.8 cents on the consumption above this level.
Stochastic Analysis	Modeling methods or analyses which use probabilities to model variables with random, or stochastic, characteristics.
Stranded costs/investment	Costs of a utility that cannot be recovered from market prices (for example, an electrical utility's assets that would become uneconomic in a competitive market), or that would become "stranded" if consumers chose a different supplier.
Supply mix	The supply mix refers to the different types of generation (such as different fuel types) that are used to produce electricity in a particular electricity system. Supply mix is often expressed in terms of the proportion of each generation type within the overall amount of energy produced.
Sustainable Development	Has been defined as development that "meets the needs of the present without compromising the ability of future generations to meet their own needs." In terms of power system planning, sustainable development means working to balance environmental, social, and economic aspects of the electric system. In developing supply mix advice, life-cycle environmental impacts of different generation options have been taken into account. Social aspects have been considered in terms of the reliability and adequacy of the electric system. Economic aspects have been assessed in terms of the relative life-cycle costs of the different options under consideration.
System interconnection	A physical connection between two electric systems that permits the transfer of electric energy in either direction.
System operator	The entity with the responsibility to monitor and control an electricity system in real time.
Thermal efficiency	A measure of the efficiency of converting a fuel to energy and useful work; calculated by dividing useful work or energy output by higher heating value of input fuel times 100.
Time of use rates	An electricity pricing scheme that is time sensitive over the day, day of week and/or season. Prices are higher when the demand for energy is highest. Typical peak hours are during weekday mornings and evenings. During low demand hours prices are lower.

Total resource cost (TRC) test	A benefit-cost test which measures the net costs of a demand side program, including both the participants' and the utility's costs. The benefits for the TRC test are avoided costs of generation.
Transmission	The movement or transfer of electrical energy over an interconnected group of lines and associated equipment between points of supply and points at which it is transformed for delivery to consumers, or is delivered to other, separate transmission systems. Transmission of electricity is done at high voltages (50kV or higher in Ontario); the energy is transformed to lower voltages for distribution over local distribution systems.
Volt (V)	The volt is the International System of Units (SI) measure of electric potential or electromotive force. A potential of one volt appears across a resistance of one ohm when a current of one ampere flows through that resistance.
Watt (W)	The unit of electrical power equal to one ampere under a pressure of one volt. A Watt is equal to 1/746 horsepower.
Watt-hour (Wh)	The electrical energy unit of measure equal to one watt of power supplied to, or taken from, an electric circuit steadily for one hour. A device which draws one watt of power over one hour consumes one watt-hour of energy, as does a 60 watt light bulb operating for one minute.
Wholesale market	The market in which electricity and other energy services are sold to directly connected customers, wholesalers, retailers, and distributors, who in turn sell to retail or end-use customers.
Wind energy	Electricity produced from a system of airfoils or blades that spin a drive shaft to capture the kinetic energy of the wind. The amount of energy in wind is proportional to the wind speed cubed.

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Addendum 1:
ICF Consulting Report: Assessment of Energy Efficiency Potential: 2006-2025, August 2005

Addendum 2:
ICF Consulting Report: Assessment of Energy Efficiency Potential: 2006-2025, October 2005

Note:
Part 4.2 has expanded explanatory text and the same results as the October 2005 report.

Volume 4 – Supply Mix Submissions and Presentations (Web Only)

4.1 Navigant Consulting PSM Report Final

4.2 ICF Report on CDM Potential with appendices November 2005 (note: see also Chapter 3 addendum on Disk 1)

4.3 CERI Report to OPA - August 24 2005

4.4 SENES Final Report to OPA

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4.6 Helimax Report on Wind to OPA - November 24 2005

Volume 5 – Supply Mix Consulting Reports

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